

T I T L E P A G E


DEVELOPMENT AND BUILD OF PROTOTYPE TOOLS FOR
INDUCTION BRAZING OF STAINLESS STEEL
TUBING AND FITTINGS FOR NASA
APPLICATIONS

Final Report

Prepared for George C. Marshall Space Flight Center, Huntsville,
Alabama.

Technical Information Series Report No. R66FPD47
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Prepared under Contract No. NAS8-11554 Control No. 1-4-8-00001
(IF) by the Braze Development Laboratory, Large Jet Engine
Department, Flight Propulsion Division, General Electric Co.,
Evendale, Ohio


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Author

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FORWARD

This final report covers the work performed under NASA Contract NAS8-11554, Control No. 1-4-8-0000 (IF). The contract work included the design and manufacture of sizing equipment for the tubing to be brazed; the design of couplings, elbows and tee type braze fittings; the development and manufacture of split type induction braze tools for these fittings; the design and manufacture of debraze tooling; the evaluation of high frequency induction brazing on heavy wall large O.D. tubing; and the training and instruction of Marshall Space Flight Center personnel in the use of these tools.

This program was conducted in the Braze Development Laboratory, Manufacturing Process Applications Development, Large Jet Engine Department, Flight Propulsion Division, General Electric Co., Evendale, Ohio. George F. Albers, Supervisor of the Braze Development Laboratory, was the Program Manager and Don H. Greisl of the Braze Development Laboratory was the Project Engineer for the program.

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ABSTRACT

N67-11687

The design and manufacture of sizing tools for the tubing to be brazed; the design of couplings, elbows and tee type fittings; the design and manufacture of split type induction tools to braze these fittings to the tube ends; the design and manufacture of the debrazing tools; and the use of high frequency induction brazing of heavy wall tubing (.188 wall thickness - O.D. 2") are described in this report.

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NO. R66FPD47

INTRODUCTION

The systems and components of rocket propulsion vehicles must function under severe environmental operating conditions. Rocket propulsion fluid systems, in particular, are subjected to extremes of temperature, pressure and vibration for short periods of time. The standard threaded type aircraft engine fittings currently being used for tubing connections in rocket propulsion fluid systems are inadequate. Leakage can occur when the vehicle is exposed to operating conditions. Advanced tube joining methods are required which will provide zero leakage and light weight with a high degree of operational reliability.

Techniques for making "on engine" tubing connections by induction brazing had been developed by the Brazing Development Laboratory, Large Jet Engine Department, Flight Propulsion Division, General Electric Company, Evendale, Ohio for use on the J93 Engine used to power the XB-70 air vehicle. This technique was considered feasible and worthy of further development for joining advanced rocket propulsion fluid tubing systems.

The purpose of this program was to design, develop, manufacture and demonstrate induction brazing and related tooling and connectors for fluid tubing systems on rocket propulsion vehicles.

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NO. R66FPD47

TOOLING

The NASA contract required the design and construction of six (6) split coil inductors (one of each size) for brazing 1/4", 3/4", 1 1/4", 1 1/2", 2" and 2 1/2" tubing using a straight coupling: the design and manufacture of five (5) split coil inductors (one of each) for brazing the pre-mentioned tubing sizes except the 2 1/2" for elbow and tee type fittings; the design and building of sizing equipment for sizing tubing to a controlled diameter in the following size tubing: 1/4", 3/8", 1/2", 3/4", 1", 1 1/4", 1 1/2", 2" and 2 1/2"; the design and building of debrazing equipment, (one of each) for 1/4", 3/4", 1 1/4", 1 1/2", 2" and 2 1/2".

The development of each type tool will be reviewed in detail. Each aspect of the process is defined and each applicable tool discussed.

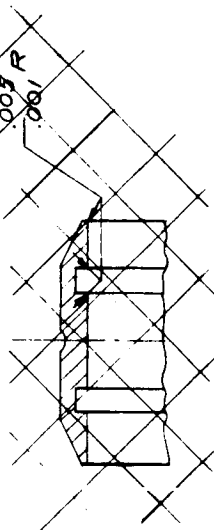
Split Inductors For Straight Couplings

The basic process consists of induction brazing tubing and couplings together to produce a strong, leak-resistant joint. This is accomplished by assembling a coupling, containing pre-placed braze alloy (print 871C234) equally over two tube ends and induction heating the area to the braze alloy flow temperature.

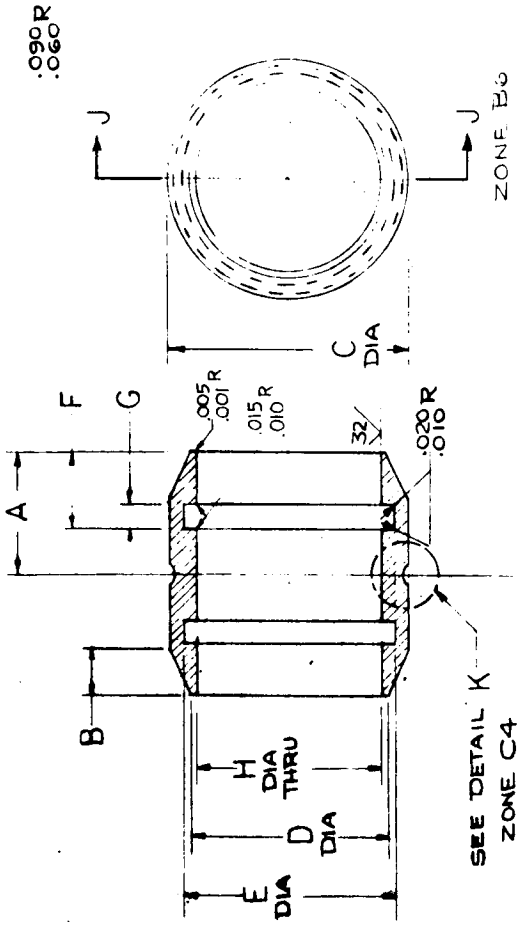
To satisfy these requirements the split coil inductors must exhibit the following characteristics: a split induction heating coil having the effect of one continuous wound coil, a split atmospheric chamber with inert gas inlets and outlets, and a chamber that houses the split coils with an air cooling manifold.

The split atmospheric chamber permits visual observation of the joint during the brazing operation. It also envelopes the joint providing an oxygen free atmosphere. An advantage of being able to see the joint during the brazing operations is that if the automatically allotted time does not produce a good braze joint, manual control of the heating cycle can be assumed until the alloy has flowed and formed a sound joint. Secondly, melting of the braze alloy can be observed or monitored visually. Melting is evident by a dark shadow seen on the coupling representing the braze alloy as it melts and starts to flow.

| 871C234 P04 | 2.50 | .332 | .103 | .357 | .307 | .302 | .158 | .063 | .251 |
|-------------|-------|------|------|-------|-------|-------|------|------|-------|
| | | .322 | .083 | .352 | .281 | .297 | .149 | .058 | .250 |
| P05 | .312 | .332 | .111 | .428 | .370 | .365 | .176 | .063 | .313 |
| | | .322 | .091 | .423 | .350 | .360 | .156 | .059 | .312 |
| P06 | .375 | .303 | .119 | .499 | .432 | .428 | .194 | .077 | .376 |
| | | .293 | .099 | .494 | .412 | .423 | .174 | .072 | .375 |
| P07 | .438 | .332 | .127 | .620 | .496 | .500 | .211 | .063 | .439 |
| | | .322 | .107 | .615 | .476 | .495 | .191 | .058 | .438 |
| P08 | .500 | .333 | .135 | .642 | .560 | .572 | .228 | .063 | .501 |
| | | .323 | .115 | .637 | .540 | .567 | .208 | .058 | .500 |
| P010 | .625 | .369 | .166 | .781 | .682 | .697 | .260 | .077 | .626 |
| | | .359 | .146 | .776 | .662 | .692 | .240 | .072 | .625 |
| P012 | .750 | .400 | .213 | .877 | .807 | .822 | .292 | .092 | .751 |
| | | .390 | .193 | .872 | .787 | .817 | .272 | .087 | .750 |
| P014 | .875 | .497 | .236 | 1.002 | .932 | .947 | .339 | .101 | .876 |
| | | .437 | .216 | .997 | .912 | .942 | .318 | .096 | .875 |
| P016 | 1.000 | .495 | .260 | 1.127 | 1.057 | 1.072 | .385 | .111 | 1.001 |
| | | .485 | .240 | 1.122 | 1.037 | 1.067 | .365 | .106 | 1.000 |



VIEW BEFORE CHANGE ZONE B6



SEE DETAIL K
ZONE C4

SECT. J-J
ZONE B5

- 5 DIA E & H MUST BE CONCENTRIC WITHIN .002 FIR.
- 4 DIA H MUST BE ROUND WITHIN .0004 FIR.
- 3 COUPLINGS SHALL BE CLEANED IN A MANNER PRIOR TO PACKAGING TO REMOVE ALL DIRT, OIL, GREASE, OR FOREIGN MATERIAL DETRIMENTAL TO THE ULTIMATE BRAZING OPERATION & INDIVIDUALLY PACKAGED IN HEAT SEALED PLASTIC BAG
- 2 MARK OR TAG EACH INDIVIDUAL HEAT SEALED PLASTIC BAG WITH PART IDENT NO. & VENDOR CODE IDENT
- 1 MUST CONFORM TO G-E SI-212.010 (INTERPRETATION OF DWG)

| ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
|------|-----|---|------|----------|
| | | ECN 43880 CIDN 200185 | | |
| C | (I) | RETRACED WITH GEN. CHGS CIDN 200460 | | |
| D2 | (I) | VIEW BEFORE CHANGE CIDN 200558 | | |
| E | (I) | P5, P7, & P14 ADDED ECN 130137 | | |
| F | (I) | PART 5 C DIA WAS .423-.438 ECN 44836 | | |
| H | (I) | NOTE 2 WAS: MARK CONTAINER OR TAG WITH PART IDENT NO. AND VENDOR CODE IDENT CIDN 201190 | | |

| | | | |
|-----|---------|------|---------------|
| REV | 871C234 | SIZE | CONT ON SHEET |
|-----|---------|------|---------------|

| | | | |
|----------------------------|--|--------------|--|
| GENERAL ELECTRIC | | 85307 | |
| COUPLING-TUBE, BRAZED ENDS | | 871C234 | |
| DRAWN | | DATE | |
| APPROVED | | ISSUED | |
| MATERIAL | | ENG. NO. | |
| G-E | | MATL. NO. | |
| FOR G-E USE ONLY | | CHECKER | |
| SIM TO N° | | PROCESS INFO | |
| L/O NO. | | L/O NO. | |
| JW | | JW | |

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TECHNICAL INFORMATION SERIES
NO. R66FPD47

Manufacture Of Atmospheric Chamber

Pyrex tubing of the correct diameter is split off center lengthwise and lapped flat to the correct dimension. One half of the tube is scrapped for being undersize. This is compensated for, by the advantage that matched halves are not a requirement. One half can be replaced with another tube half with the assurance that an adequate atmospheric chamber is being obtained.

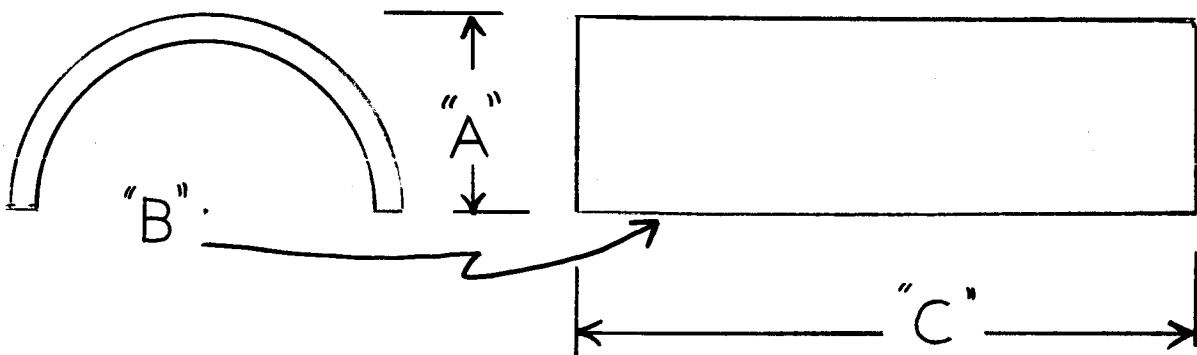
A water-cooled metallurgical cut-off machine utilizing a glass cutting wheel, was used to perform the splitting operation. Cutting dimensions were obtained by the use of a plexiglass guide block attached to the travel table on the cut-off machine. Little difficulty resulted with this cutting technique. The split tube contact surfaces were relatively chip free, but untrue. An aluminum oxide (grinding wheel - fine grit) served as the lapping plate to correct the contact surface. Dimensional checks were taken periodically to ascertain the quality of this operation. The lapping method is a light, even hand stroke in one direction at all times. The quality was exceptionally good, chipping was almost negative, and a $\pm .002$ " on altitude and a .005" F.I.R. on surface flatness could be maintained. This method is acceptable for producing the split atmospheric chamber. Table I lists the final configurations and dimensions.

Splitting glass for the elbow and tee type tool is accomplished in the same manner as for the straight coupling tools. One difference exists between the two types of tool glass. For the elbow and tee type tools, the glass is molded to the required diameter by placing the split glass in a ceramic mold and yielding (forming) at a temperature of 1500°F for five (5) minutes.

This molding of the glass insures tighter control on glass dimensions, assuring more efficient sealing at the split line. Standard pyrex tubing in larger diameters has greater tolerances on the O.D. and I.D. than is needed for (split induction braze tools) sealing chambers. Molding of the glass also eliminates the problem of using several different size O'Rings to hold the glass in place. Table II lists the final configurations and dimensions.

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TABLE I. Tolerances For Glass Tools Used
 In Brazing Straight Couplings



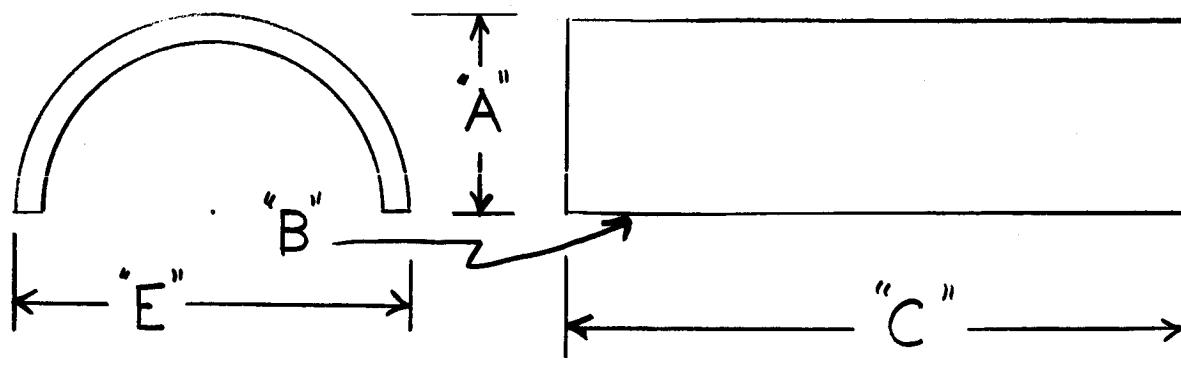
Surface "B" to be flat w/in .0005 F.I.R. and surface "B" parallel to top of tubing w/in .003 in.

| <u>O.D. Brazen Tube</u> | <u>Tube O.D. (MM)</u> | <u>Tube Wall (MM)</u> | <u>Dim. "A" Inches</u> | <u>Dim. "C" Inches</u> |
|-----------------------------|---------------------------|---------------------------|----------------------------|----------------------------|
| 250 | 13.4 | 1.3 | .266 | 2.26 |
| | 12.6 | 1.1 | .251 | 2.24 |
| 750 | 28.7 | 1.7 | .550 | 2.26 |
| | 27.3 | 1.3 | .535 | 2.24 |
| 1.250 | 46.0 | 2.2 | .897 | 3.63 |
| | 44.0 | 1.8 | .882 | 3.61 |
| 1.500 | 52.0 | 2.2 | 1.015 | 3.63 |
| | 50.0 | 1.8 | 1.000 | 3.61 |
| 2.000 | 76.3 | 2.7 | 1.487 | 3.63 |
| | 73.7 | 2.1 | 1.474 | 3.61 |
| 2.500 | 81.3 | 2.7 | 1.536 | 3.63 |
| | 78.7 | 2.1 | 1.521 | 3.61 |

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NO. R66FPD47

TABLE II. Glass Tolerances For Elbow
And Tee Type Tools



Surface "B" to be flat w/in .0005 F.I.R. and Surface "B'" parallel to top of tubing w/in 003 in.

| Brazed Tube O.D. | Tube O.D. Nom. (MM) | Tube Wall Nom. (MM) | Dim. "A" Inches | Dim. "C" Inches | Dim. "E" Inches |
|---------------------|------------------------|------------------------|--------------------|--------------------|--------------------|
| .250 | 13.0 | 1.2 | .260 .255 | 1.32 | .520 .510 |
| .750 | 28.0 | 1.5 | .5675 .5625 | 1.57 | 1.135 1.125 |
| 1.250 | 45.0 | 2.0 | .880 .875 | 1.95 | 1.760 1.750 |
| 1.500 | 51.0 | 2.0 | 1.005 1.000 | 1.95 | 2.010 2.000 |
| 2.000 | 70.0 | 2.4 | 1.400 1.395 | 2.32 | 2.800 2.790 |

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Split Coil Inductors And Housing Block

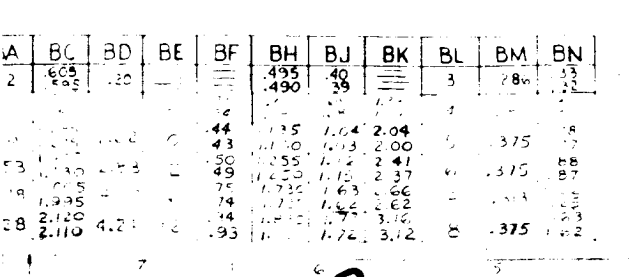
The coils are supplied in equal halves, but function as one continuous wound coil. Coils are housed in a rigid chamber of RPD 150 (composed of preimpregnated long spinning grade chrysotile asbestos fibers and a high heat resistant phenolic resin system) material and containing an air manifold for cooling of all coil halves. The coil is so constructed that if one portion of the coil were accidentally damaged it could easily be replaced, preventing the loss of a complete coil. The individual coil segments are contained and positioned in RPD 150 block by means of two small screws. Between the two screws is an air passage from the manifold to the coil segment, thus cooling each segment separately. Air is discharged on the O.D. of each coil near the split line thru a small hole drilled in the coil segments as seen in Figure 1 and 1.A.

The cooling air in the 1/4" tool enters from one side of the coil and travels through the coil discharging at the opposite opening (See figures 2 & 2A). These particular split coil inductors are for brazing the 1/4", 3/4", 1 1/4", 1 1/2", 2" and 2 1/2" tube joints with straight connectors. Table III lists the split coil data for the above mentioned coils. Several other features of the split coil inductors are:

1. A flexible copper braided joint at the pivot point of the clamp allowing freedom of movement while in operation.
2. A special copper cable connecting pin, silver brazed to the end of each coil lead.
3. A double argon feed system to prevent a heat sink.
4. Ease of opening and closing of split coil.
5. Extra argon channel between O'Rings to prevent oxidation.

Figures I through 6A are the split inductors delivered to NASA for use in brazing straight couplings, print 4012180-651.

2

[illegible]

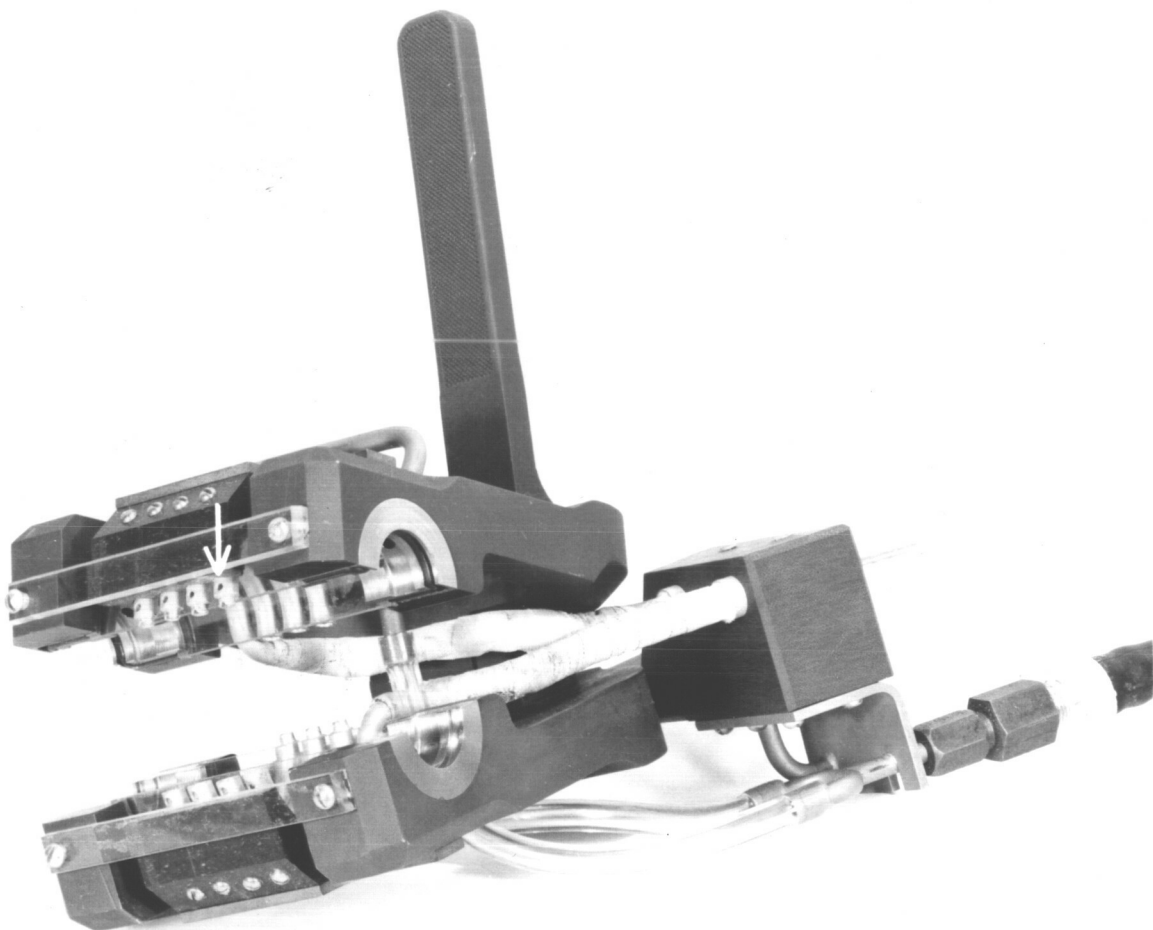


Figure 1

AIR DISCHARGE HOLES

MO4761

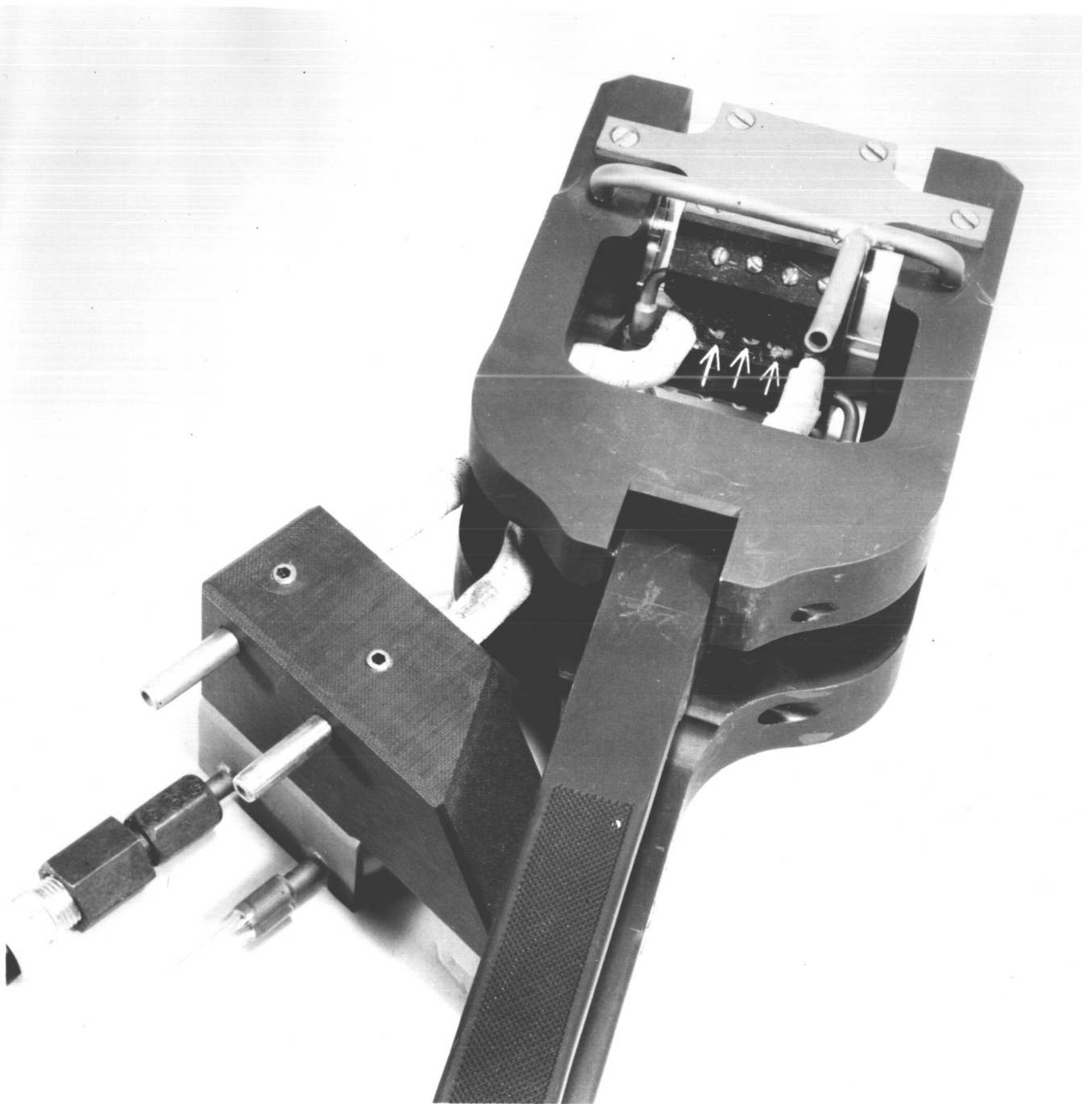


FIGURE 1 A

AIR DISCHARGE HOLES
(3/4" Braze Tool)

MO4761

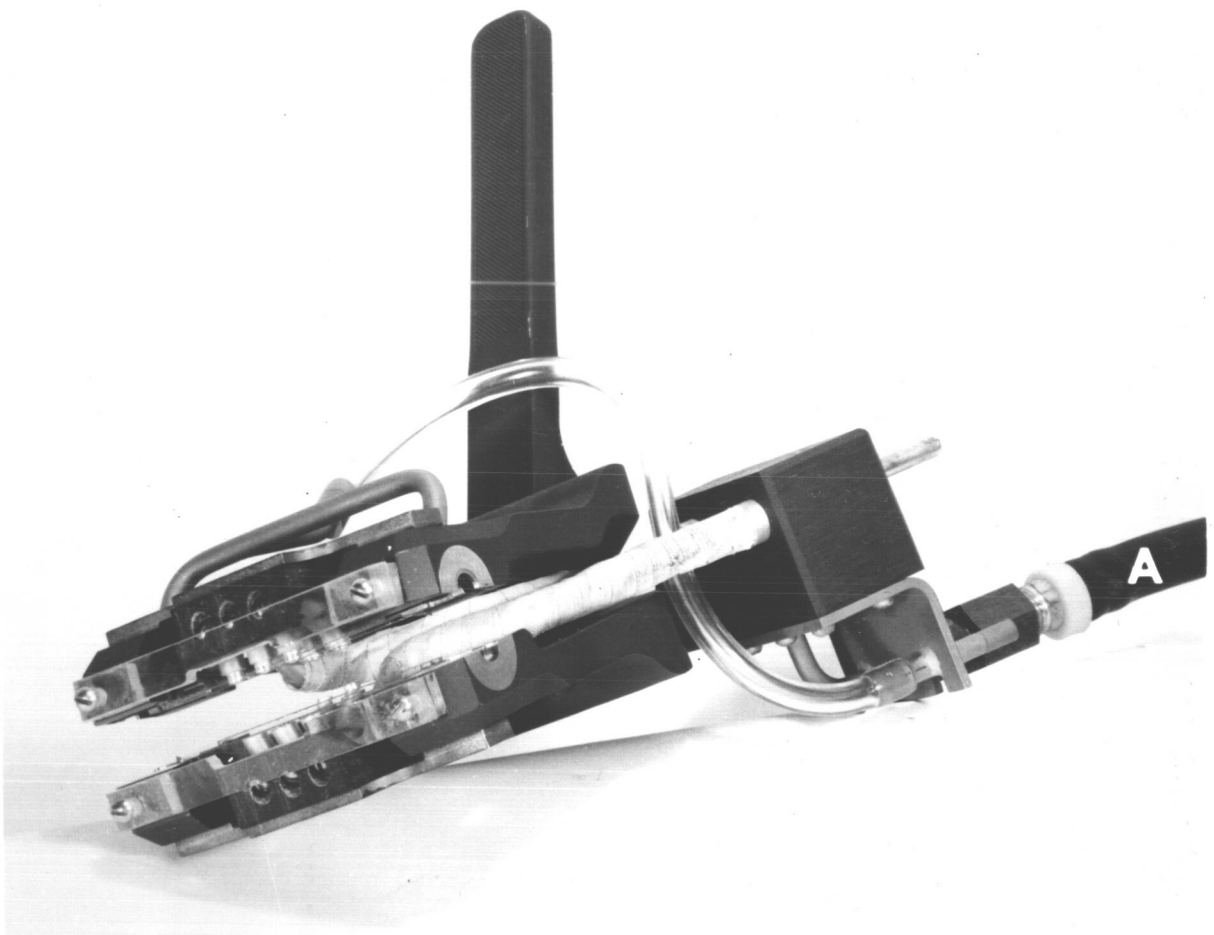


FIGURE 2

1/4" BRAZE TOOL
(A-Air Inlet)

MO4761

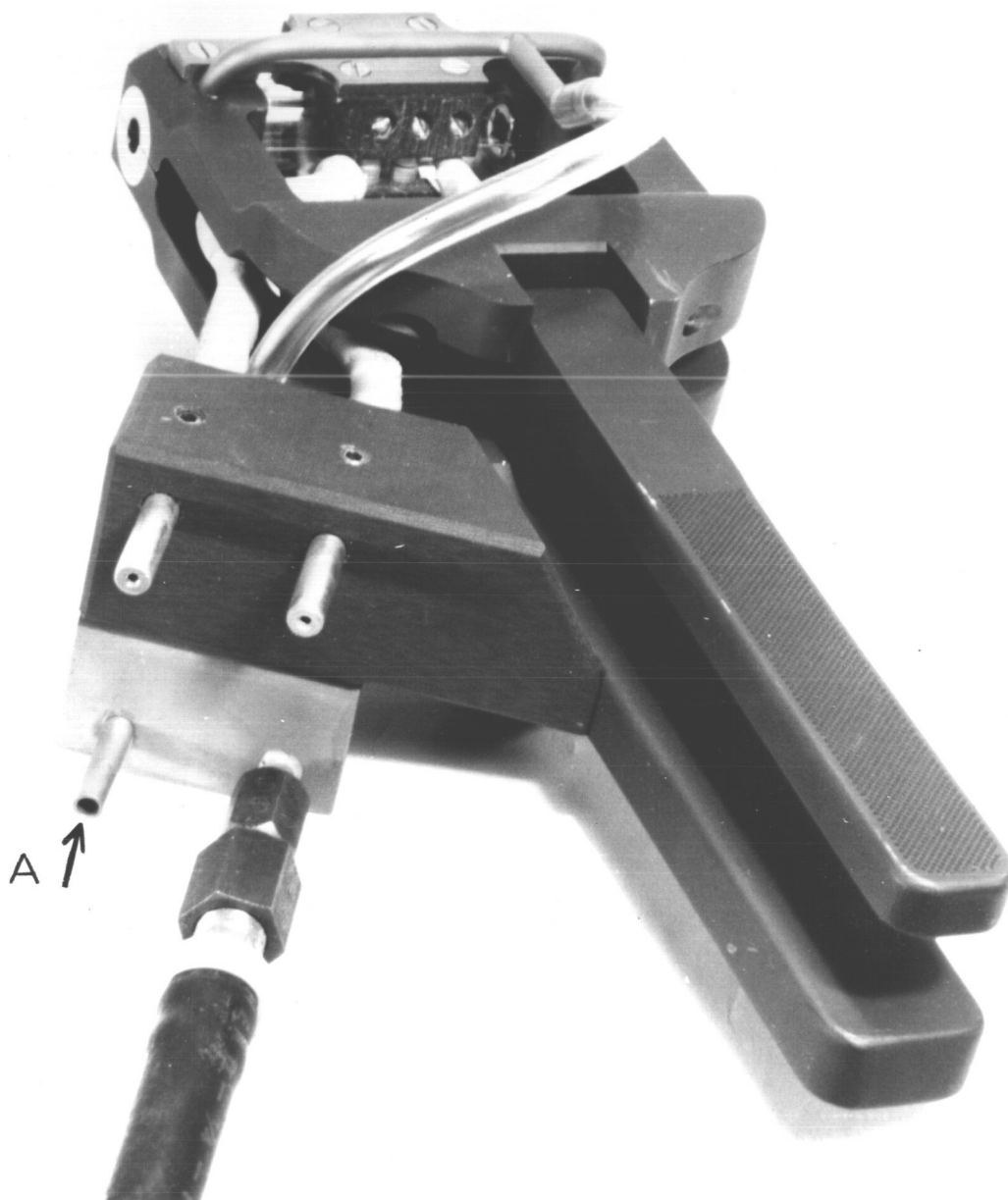


FIGURE 2A

1/4" BRAZE TOOL
(A-Air Discharge)

MOL761

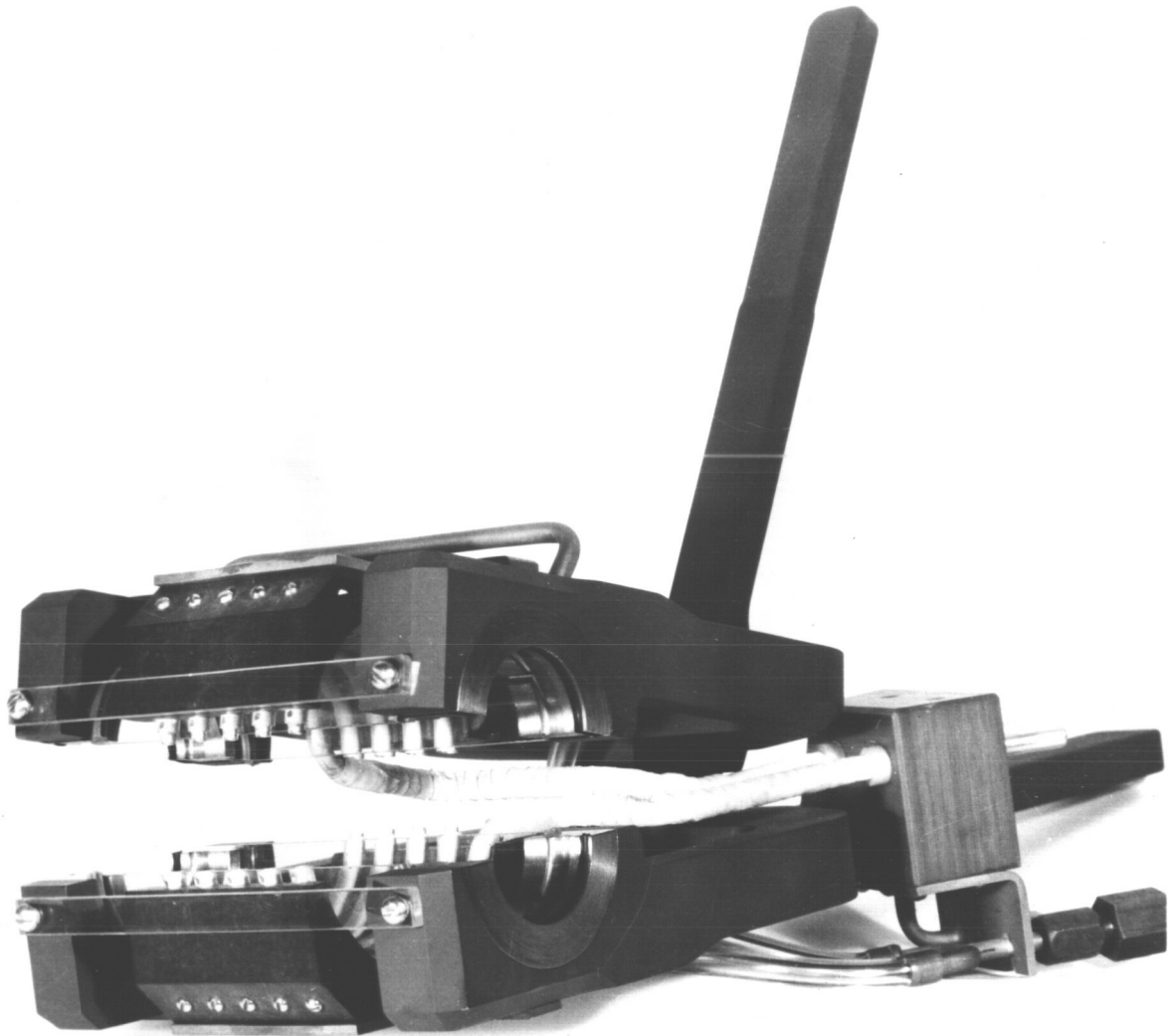


FIGURE 3

1 1/4" BRAZE TOOL

MO4761

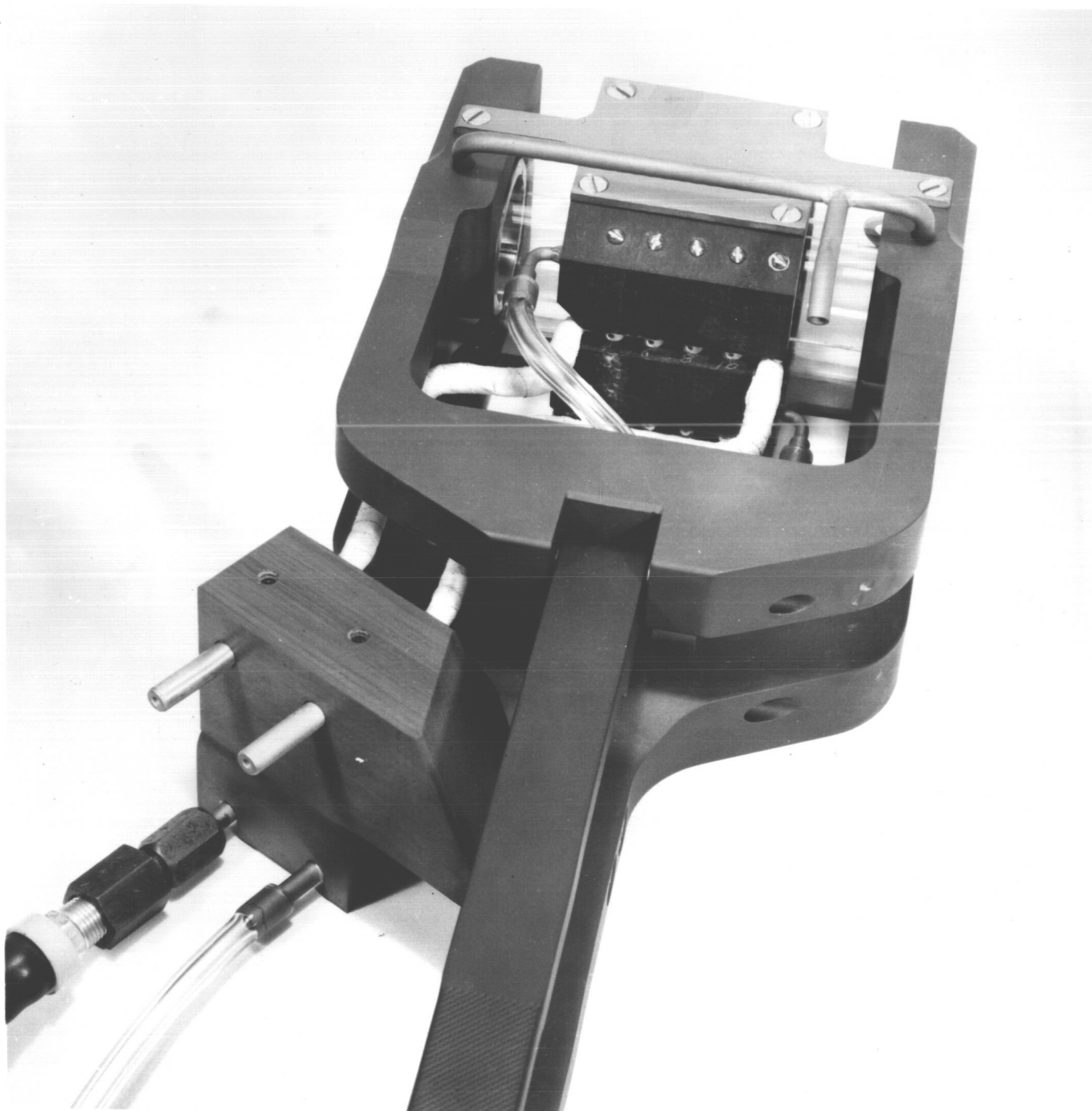


FIGURE 3A

1 1/4" BRAZE TOOL

MO4761

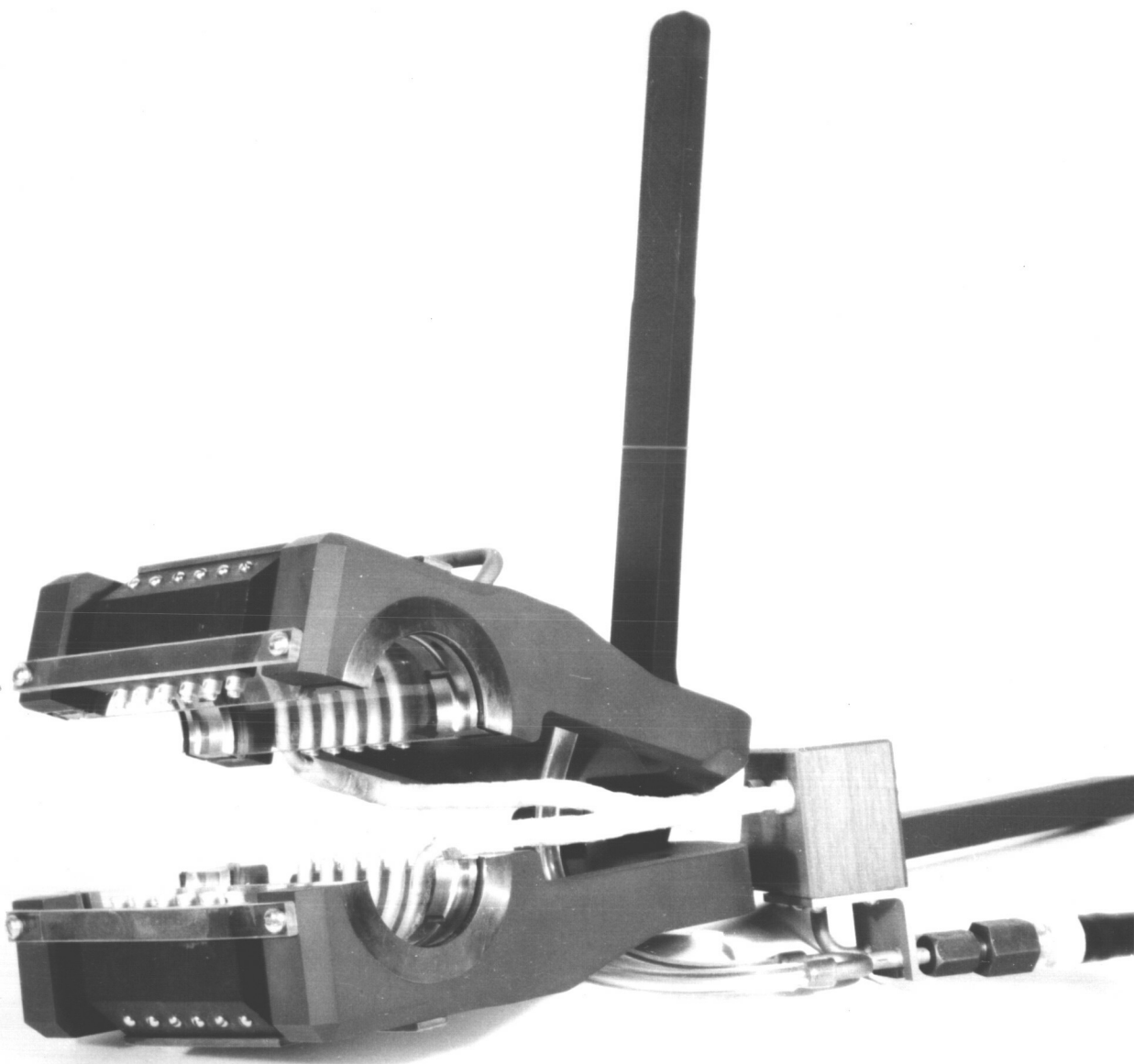


FIGURE 4

1 1/2" BRAZE TOOL

MO4761



FIGURE 1A

1 1/2" BRAZE TOOL

MO4761

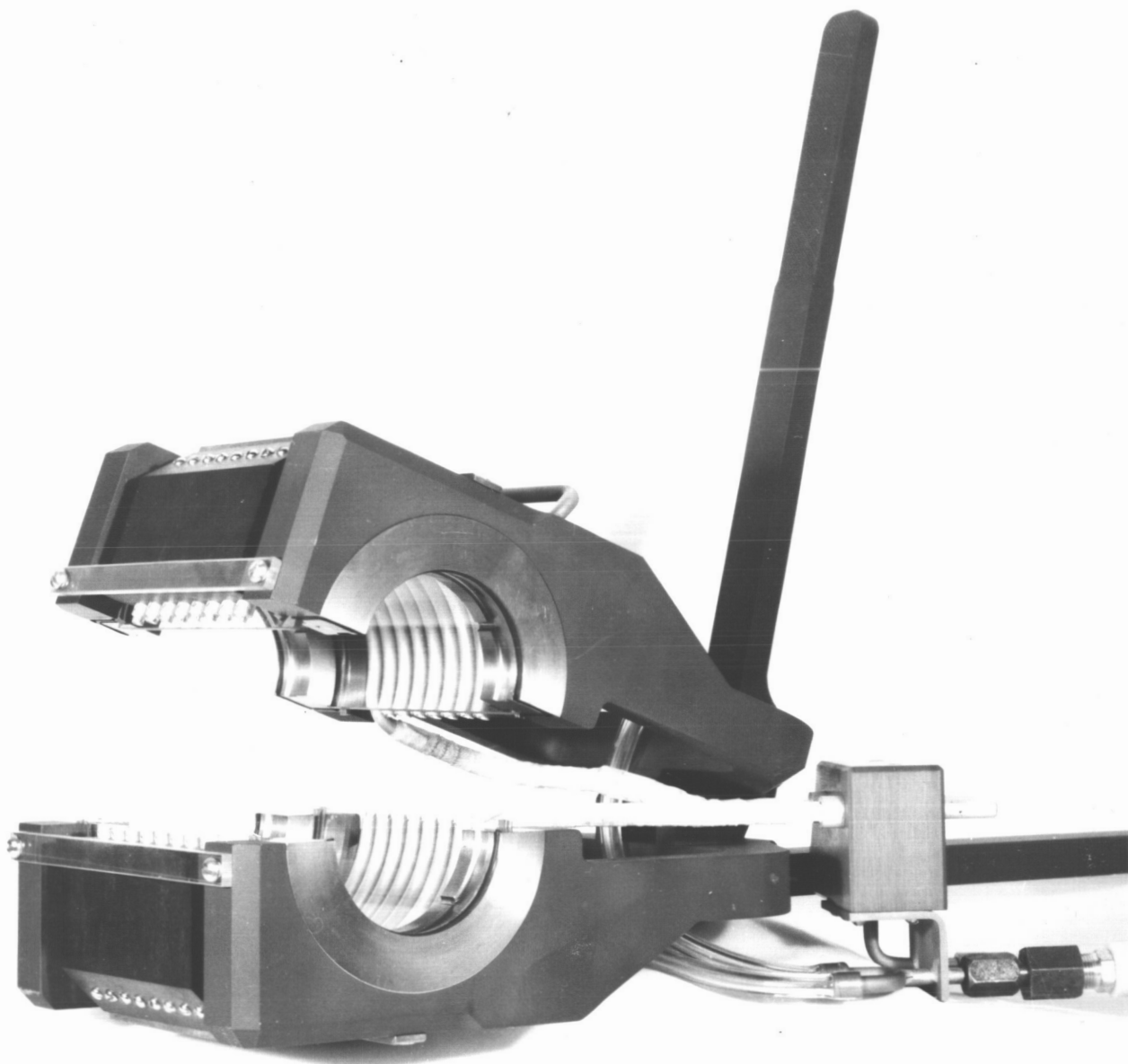


FIGURE 5

2" BRAZE TOOL

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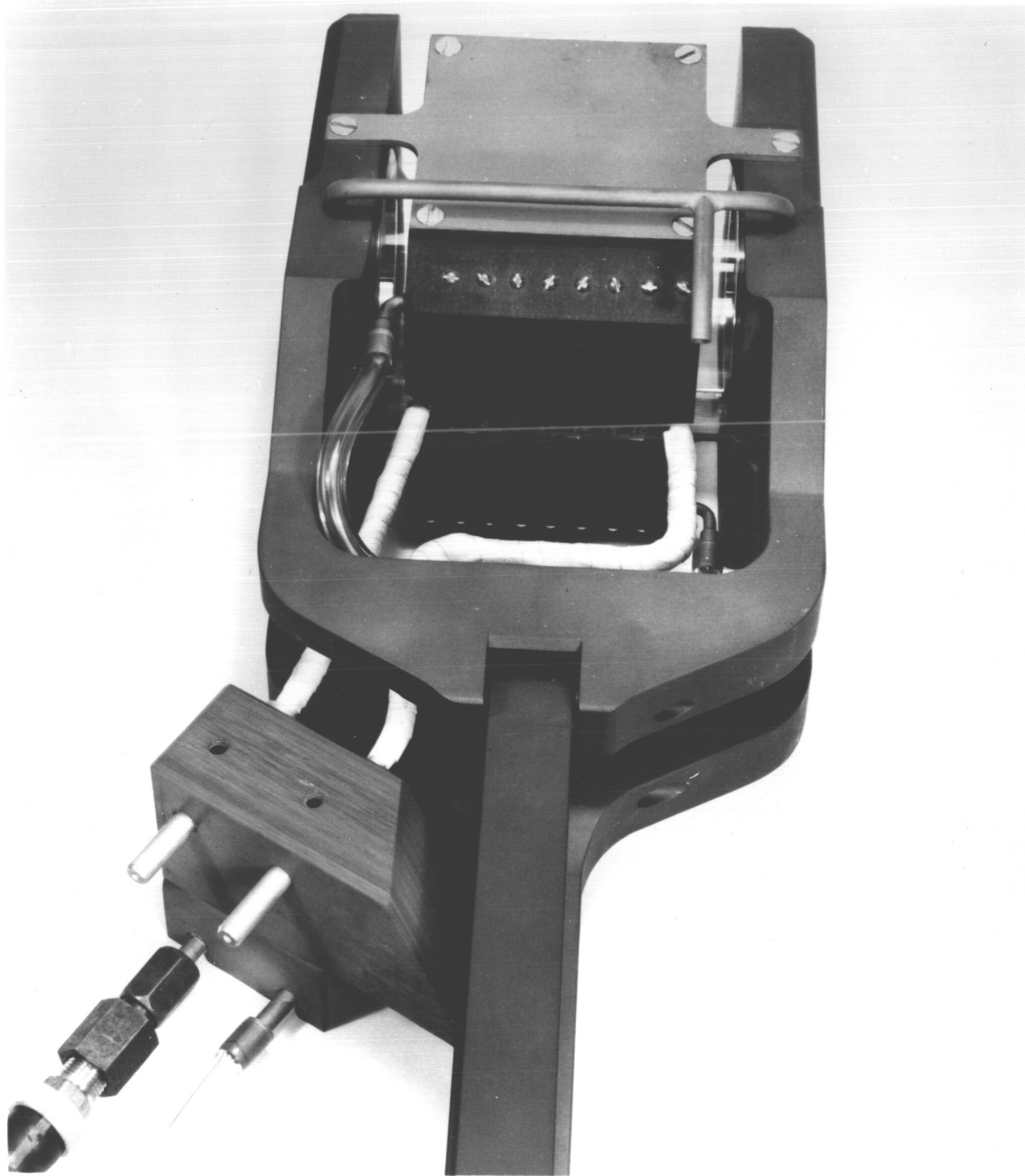


FIGURE 5A

2" BRAZE TOOL

MO4761

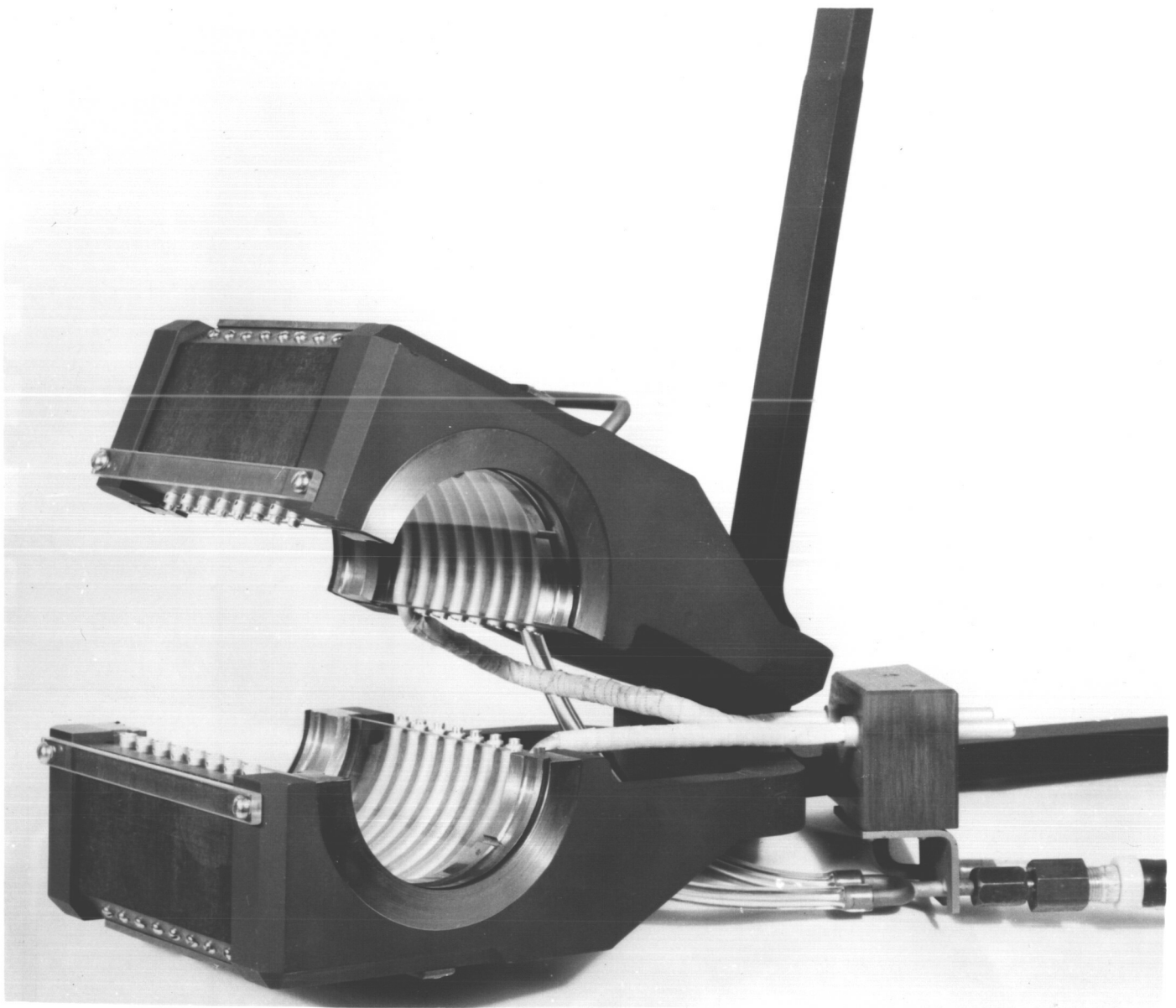


FIGURE 6

2 1/2" BRAZE TOOL

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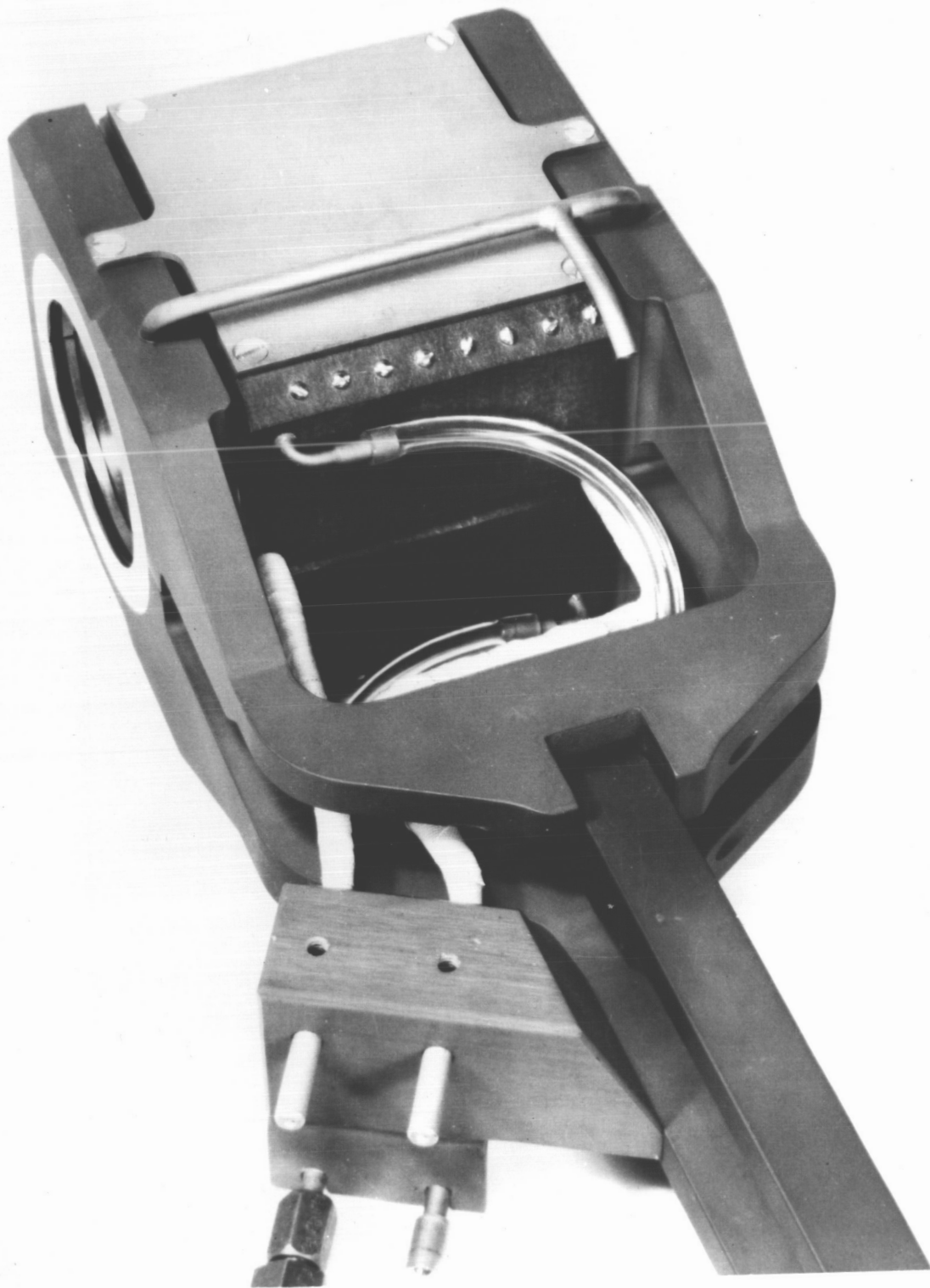


FIGURE 6A

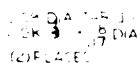
2 1/2" BRAZE TOOL

NO4761

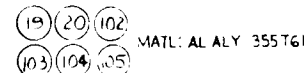
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NO. R66FPD47

INDUCTORS FOR ELBOW AND TEE FITTINGS

Housing of the split coil inductor for brazing elbow and tee type fittings is similar to that used for the coil for brazing straight couplings. The coil itself is made from square copper tubing instead of round which was used for straight couplings coil. Square copper tubing was used to gain additional surface area needed for efficient heating of these fittings. Greater efficiency could be achieved with coils having a larger surface area, due to the fact that high-frequency currents tend to flow along the surface of the metal. By using square copper tubing the number of turns were reduced, allowing shortening of the straight length required to make a coil for brazing elbow and tee type fittings. The width of the brazing tool was thus reduced. The coil itself has a safety wiper blade attached on the back side of the coil where the coil joins at the split line of the glass chamber. The wiper blade not only insures good electrical contact, but also acts as a shield which prevents back flow of discharged cooling air. As was mentioned previously, the glass for these tools is molded giving tighter control on tolerances and assuring a better atmosphere chamber. The sealing jaws of these tools are made of the RPD 150 material to reduce weight of the tool. The jaws themselves have a double O'Ring groove to insure better sealing. Figure 7 thru 11 show the 1/4" braze tool through the 2" braze tool for brazing the elbow and tee type fittings. Figure 12, 12A and 12B show the braze tools with their carrying case. For details of these tools see prints, 4012180-740 thru 744.



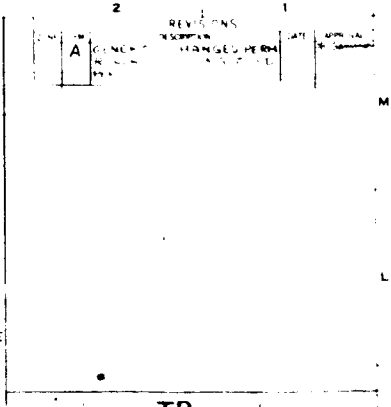
| PART No. | CA | CB | CD | CE | CF | CH | CI | CJ | CK | CL | CM | CN | CP | CR | CS | CT | CV | CW | CX |
|----------|----------------|--------|----------------|------|----------------|------|----------------|----|-----------------|----------------|---------------|------------|----------|-----|-----|-----|----|---------------|------|
| 7 | 605 595 | 5 6 | 687 7 | 68 | $\frac{3}{32}$ | 2.50 | $\frac{1}{32}$ | | $\frac{11}{32}$ | $\frac{1}{32}$ | $\frac{1}{2}$ | 475 475 | 25 25 | .27 | .27 | .16 | | | ANGL |
| 8 | 605 595 | 5 6 | 687 7 | 1.00 | | | | | $\frac{11}{32}$ | $\frac{1}{32}$ | | 475 475 | 25 25 | | | | | | |
| 9 | 1.559 1.557 | 3 4 | 1.559 1.557 | 1.34 | $\frac{1}{16}$ | 1.5 | | | $\frac{3}{32}$ | $\frac{1}{32}$ | | 640 640 | 35 35 | .29 | .56 | .25 | 4 | $\frac{3}{4}$ | |
| 10 | 1.488 1.488 | | 2.194 2.192 | 1.50 | $\frac{1}{2}$ | 4.50 | | | $\frac{3}{32}$ | $\frac{1}{32}$ | | 640 640 | 35 35 | .29 | .56 | .25 | 4 | $\frac{3}{4}$ | 15° |
| 11 | 2.01 2.00 | | 3.150 3.148 | 2.06 | 2 | 5.00 | | | $\frac{3}{32}$ | $\frac{1}{32}$ | | 640 640 | 35 35 | .29 | .56 | .25 | 5 | $\frac{1}{2}$ | 30° |
| 12 | | | 3.346 3.344 | 2.18 | 2 | 5.00 | | | $\frac{3}{32}$ | $\frac{1}{32}$ | | 640 640 | 35 35 | .29 | .56 | .25 | 5 | $\frac{1}{2}$ | 30° |



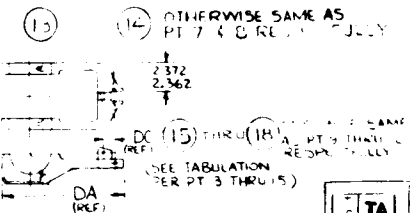
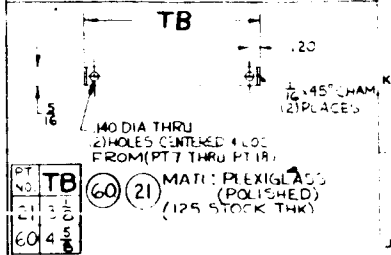
| | | | | | | |
|----------|-----------------|-----------------|-----------------|-----------------|-----|------------------|
| PT NO | 19 | 20 | 102 | 103 | 104 | 105 |
| TH | 5 $\frac{7}{8}$ | 5 $\frac{7}{8}$ | 9 $\frac{7}{8}$ | 9 $\frac{1}{2}$ | 10 | 11 $\frac{7}{8}$ |

| BY NO. | FH | FA | FB | FC |
|--------|------|------|------|------|
| 22 | 3.12 | 1.08 | 1.00 | 1.00 |
| 23 | 3.12 | 1.08 | 1.00 | 1.00 |
| 24 | 3.12 | 1.08 | 1.00 | 1.00 |
| 25 | 3.12 | 1.08 | 1.00 | 1.00 |
| 26 | 3.12 | 1.08 | 1.00 | 1.00 |
| 27 | 3.12 | 1.08 | 1.00 | 1.00 |
| 28 | 3.12 | 1.08 | 1.00 | 1.00 |
| 29 | 3.12 | 1.08 | 1.00 | 1.00 |
| 30 | 3.12 | 1.08 | 1.00 | 1.00 |

| PART NO | HA | HB | HC | HD |
|---------|------|-----|------|----|
| 34140 | 687 | 33 | 65 | |
| | 685 | 355 | 124 | |
| | 1957 | | 628 | |
| | 955 | | 624 | |
| | 92 | | 30 | |
| | 2190 | | 743 | |
| | 148 | | 1000 | |
| | 146 | | 399 | |
| | 344 | | 250 | |
| | 2342 | | | |

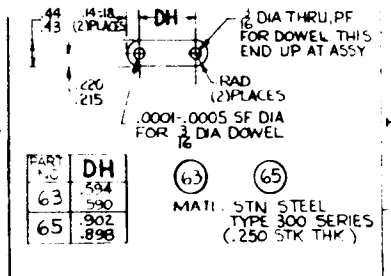
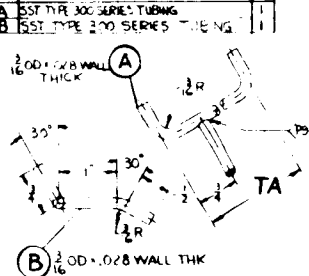


| PART NO | DA | DB | DC | DE |
|---------|-----|-----|------------|------------|
| 13 | 43 | 0° | 805 805 | 470 460 |
| 2 | 6 | 20° | 805 805 | 470 465 |
| 3 | 6 | 20° | 805 805 | 470 465 |
| 4 | 12 | 20° | 805 805 | 470 465 |
| 5 | 12 | 20° | 805 805 | 470 465 |
| 6 | 18 | 20° | 805 805 | 470 465 |
| 7 | 18 | 20° | 805 805 | 470 465 |
| 8 | 24 | 20° | 805 805 | 470 465 |
| 9 | 24 | 20° | 805 805 | 470 465 |
| 10 | 30 | 20° | 805 805 | 470 465 |
| 11 | 30 | 20° | 805 805 | 470 465 |
| 12 | 36 | 20° | 805 805 | 470 465 |
| 13 | 36 | 20° | 805 805 | 470 465 |
| 14 | 42 | 20° | 805 805 | 470 465 |
| 15 | 42 | 20° | 805 805 | 470 465 |
| 16 | 48 | 20° | 805 805 | 470 465 |
| 17 | 48 | 20° | 805 805 | 470 465 |
| 18 | 54 | 20° | 805 805 | 470 465 |
| 19 | 54 | 20° | 805 805 | 470 465 |
| 20 | 60 | 20° | 805 805 | 470 465 |
| 21 | 60 | 20° | 805 805 | 470 465 |
| 22 | 66 | 20° | 805 805 | 470 465 |
| 23 | 66 | 20° | 805 805 | 470 465 |
| 24 | 72 | 20° | 805 805 | 470 465 |
| 25 | 72 | 20° | 805 805 | 470 465 |
| 26 | 78 | 20° | 805 805 | 470 465 |
| 27 | 78 | 20° | 805 805 | 470 465 |
| 28 | 84 | 20° | 805 805 | 470 465 |
| 29 | 84 | 20° | 805 805 | 470 465 |
| 30 | 90 | 20° | 805 805 | 470 465 |
| 31 | 90 | 20° | 805 805 | 470 465 |
| 32 | 96 | 20° | 805 805 | 470 465 |
| 33 | 96 | 20° | 805 805 | 470 465 |
| 34 | 102 | 20° | 805 805 | 470 465 |
| 35 | 102 | 20° | 805 805 | 470 465 |
| 36 | 108 | 20° | 805 805 | 470 465 |
| 37 | 108 | 20° | 805 805 | 470 465 |
| 38 | 114 | 20° | 805 805 | 470 465 |
| 39 | 114 | 20° | 805 805 | 470 465 |
| 40 | 120 | 20° | 805 805 | 470 465 |
| 41 | 120 | 20° | 805 805 | 470 465 |
| 42 | 126 | 20° | 805 805 | 470 465 |
| 43 | 126 | 20° | 805 805 | 470 465 |
| 44 | 132 | 20° | 805 805 | 470 465 |
| 45 | 132 | 20° | 805 805 | 470 465 |
| 46 | 138 | 20° | 805 805 | 470 465 |
| 47 | 138 | 20° | 805 805 | 470 465 |
| 48 | 144 | 20° | 805 805 | 470 465 |
| 49 | 144 | 20° | 805 805 | 470 465 |
| 50 | 150 | 20° | 805 805 | 470 465 |
| 51 | 150 | 20° | 805 805 | 470 465 |
| 52 | 156 | 20° | 805 805 | 470 465 |
| 53 | 156 | 20° | 805 805 | 470 465 |
| 54 | 162 | 20° | 805 805 | 470 465 |
| 55 | 162 | 20° | 805 805 | 470 465 |
| 56 | 168 | 20° | 805 805 | 470 465 |
| 57 | 168 | 20° | 805 805 | 470 465 |
| 58 | 174 | 20° | 805 805 | 470 465 |
| 59 | 174 | 20° | 805 805 | 470 465 |
| 60 | 180 | 20° | 805 805 | 470 465 |
| 61 | 180 | 20° | 805 805 | 470 465 |
| 62 | 186 | 20° | 805 805 | 470 465 |
| 63 | 186 | 20° | 805 805 | 470 465 |
| 64 | 192 | 20° | 805 805 | 470 465 |
| 65 | 192 | 20° | 805 805 | 470 465 |
| 66 | 198 | 20° | 805 805 | 470 465 |
| 67 | 198 | 20° | 805 805 | 470 465 |



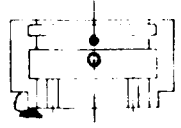
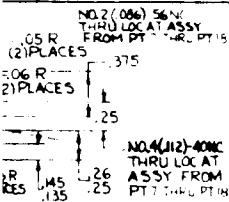
| | |
|----|------|
| TA | |
| 58 | 2.75 |
| 4 | 4.25 |

| | | |
|-----|----|-----------------|
| 6.4 | 58 | WELDED ASSEMBLY |
|-----|----|-----------------|



| PART NO | EA | | EB | | EC | | EF |
|---------|------|--------|------|--------|-------|--------|------|
| | MM | INCHES | MM | INCHES | MM | INCHES | |
| 46 | .06 | 1.1 | .051 | 1.3 | .06 | 1.26 | 2.26 |
| | .251 | 13 | .043 | 12.4 | .156 | 2.24 | 2.24 |
| 47 | .06 | 1.1 | .051 | 1.3 | .06 | 1.26 | 2.26 |
| | .251 | 13 | .043 | 12.4 | .156 | 2.24 | 2.24 |
| 48 | .06 | 2.2 | .057 | 46 | 1.311 | 3.63 | 3.63 |
| | .837 | 18 | .071 | 44.0 | 1.732 | 3.61 | 3.61 |
| 49 | .06 | 2.2 | .057 | 52.0 | 2.047 | 3.63 | 3.63 |
| | .837 | 18 | .071 | 50.0 | 1.947 | 3.61 | 3.61 |
| 50 | .06 | 2.7 | .06 | 76.3 | 3.604 | 3.63 | 3.63 |
| | .457 | 21 | .083 | 73.7 | 4.902 | 3.61 | 3.61 |
| 51 | .06 | 2.7 | .06 | 81.3 | 3.091 | 3.63 | 3.63 |
| | .536 | 21 | .083 | 79.7 | 3.023 | 3.61 | 3.61 |

(46) THRU (51) MAIL ROOM
NOTED SUP. ED TO BE AT WITHIN 10 MIN.



HF RAD
(REF)



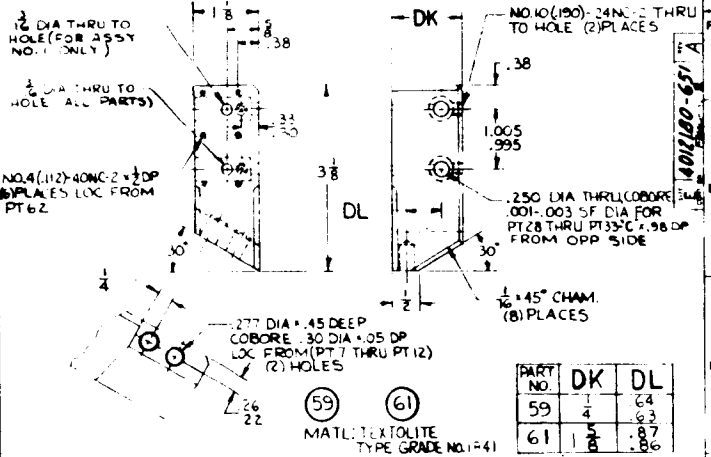
96 THRU 101

OTHERWISE SAME AS PT 40 THRU
PT 45 RESPECTFULLY
2-EACH REQ'D

| | HE | HF | HJ |
|---|-------|-------|------|
| 2 | 255 | | |
| 2 | 254 | 185 | 37 |
| 9 | | 1 | |
| 6 | 6 | .685 | 1.35 |
| 4 | 5.11 | .810 | .62 |
| 4 | 2.011 | | |
| 3 | 2.011 | 1.060 | 2.12 |
| 2 | 2.511 | | |
| | 2.50 | .810 | 2.62 |

BRAZED ASSEMBLY

| | |
|---|--|
| A | 55T TUBING TYPE 300 SERIES 3/16" OD x .028 WALL THK |
| B | 55T TUBING TYPE 300 SERIES 1/8" OD x .028 WALL THK |

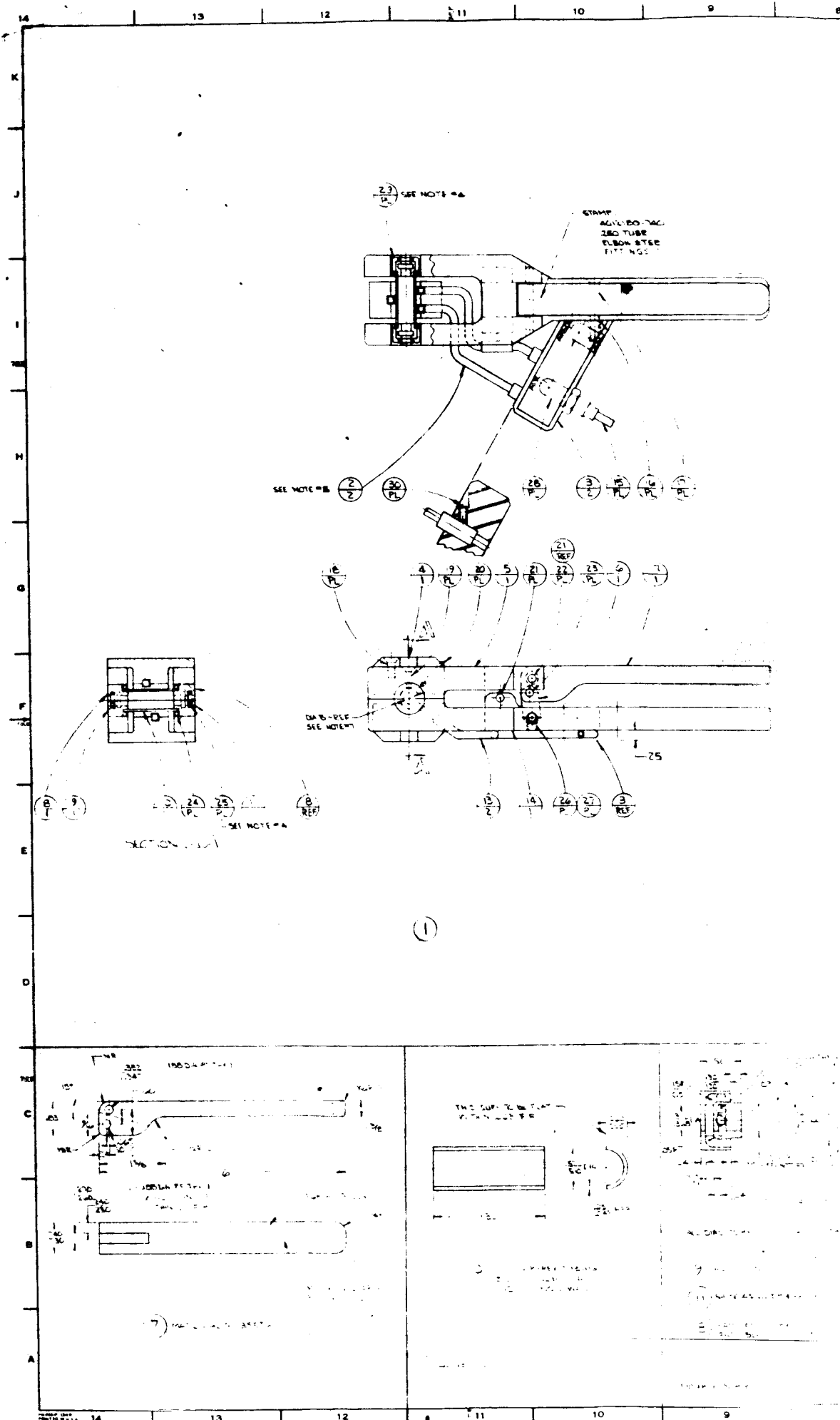


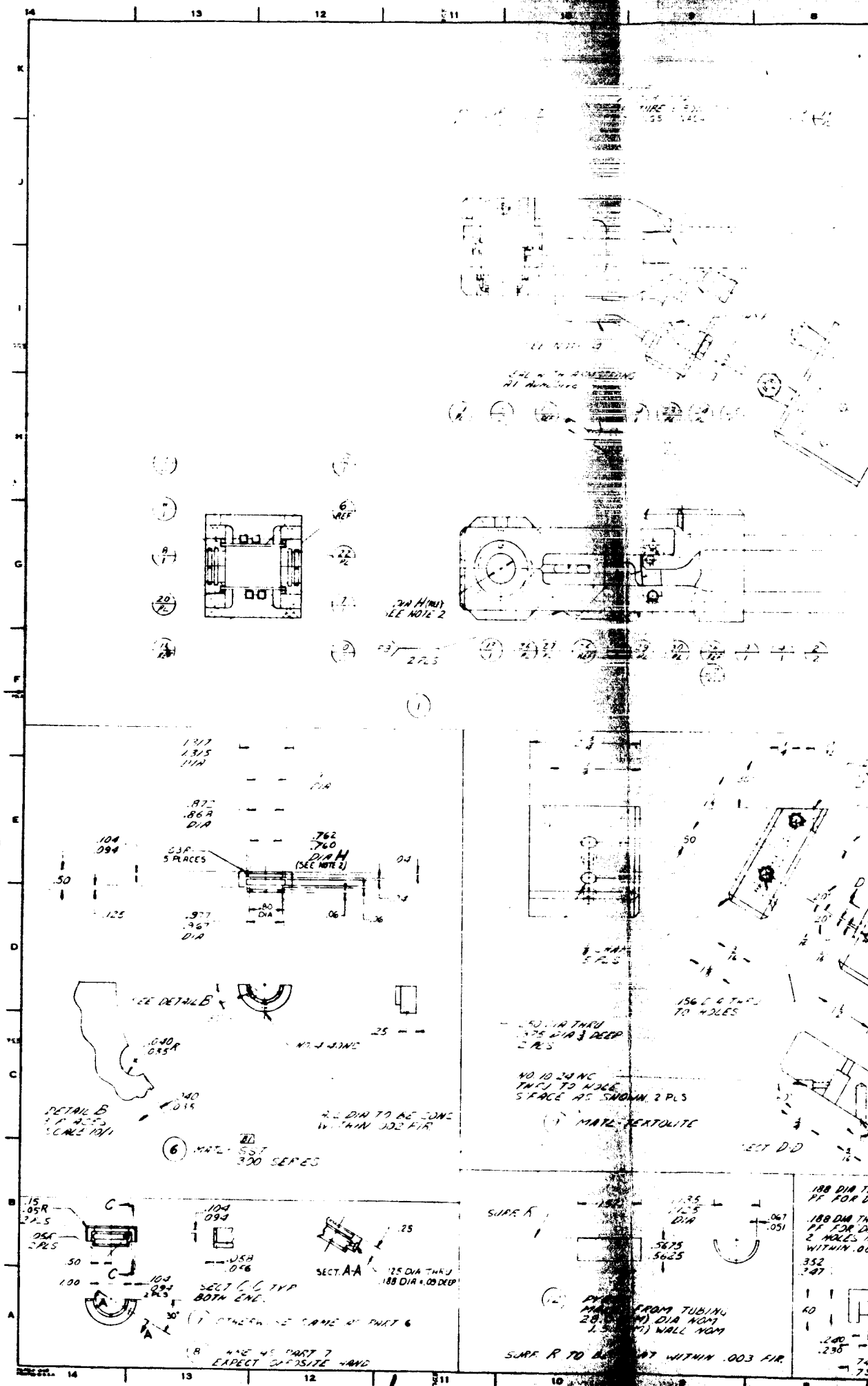
| PART NO. | DK | DL |
|----------|----------------|-----------------|
| 59 | $\frac{1}{4}$ | $\frac{64}{63}$ |
| 61 | $1\frac{5}{8}$ | $\frac{87}{86}$ |

DETAILS-
BRAZING
FIXTURE,
TUBE JOINTS

GENERAL ELECTRIC
L. E.

E 4012180-631





[illegible]

| | | |
|----|-------------------|-------|
| 12 | FRAZED ASSEMBLY | \$600 |
| - | T TYPE 770 TIRING | 1 |
| | 187500 - GBR WALL | |
| 5 | T TYPE 560 TIRING | 1 |
| | 50000 - GBR WALL | |

CRUISE AREA IN TIGER CONTAINER FOR 30
MILES FROM HONOLULU, HAWAII
ON 10/10/68 WITH "FISH" FROM THE
ELBON TEE "FISH"

1. 1/2" x 1/4" A & B SERIES 2 GIG. STILLA
2. 1/2" x 1/4" x 1/2" LENGTH TO SUIT THICK-
3. 1/2" x 1/4" x 1/2" IN PLACE WITH 6 SILICON
NO. 1000 REPAIR 2 RING 2 GROOVE
4. 1/2" x 1/4" x 1/2" WITH 6E TRANS-MENT SWIGON
5. 1/2" x 1/4" x 1/2" SEAL GENERAL ELECTRIC
6. 1/2" x 1/4" x 1/2" DEPT.

5 QUAD RING SEGMENT 103 CROSS SECTION
LENGTH TO JUT ALPESITA FINGER 9
BACKST CO.

4. YOUNG'S EMPLOYED WHEN HE COUL PART 10
WITH SOUTH ELECTRIC TALE NO-27
MINNETOTA MIN NG & MFG CO.

3 HYDUIZE PART 2384 PER AMS2470 (REL)

2 IN 4 PARTS 5, 6, 7 & 8 TO BE IN LINE AT
ASSEMBLY WITHIN 203 SEC

1. BREAK ALL SHARP EDGES

0001-0005 SF -
FOR 1875 DVA
DOWEL (THIS END
UP AT ASSEMBLY)

Hand-drawn diagram of a vertical structure, possibly a chimney or tower. The diagram includes the following labels and dimensions:

- Top left: RAD - 2.5
- Left side (vertical dimension): 2.5, 2.5A, 1.5, 1.5, 2.5
- Bottom left: 4.0, 4.30
- Right side (vertical dimension): 2.20, 2.15
- Bottom right: 1.55 DIA. PIPE, 5.74 POWER

(14) MATL SET TYPE
300 SERIES
50 INK

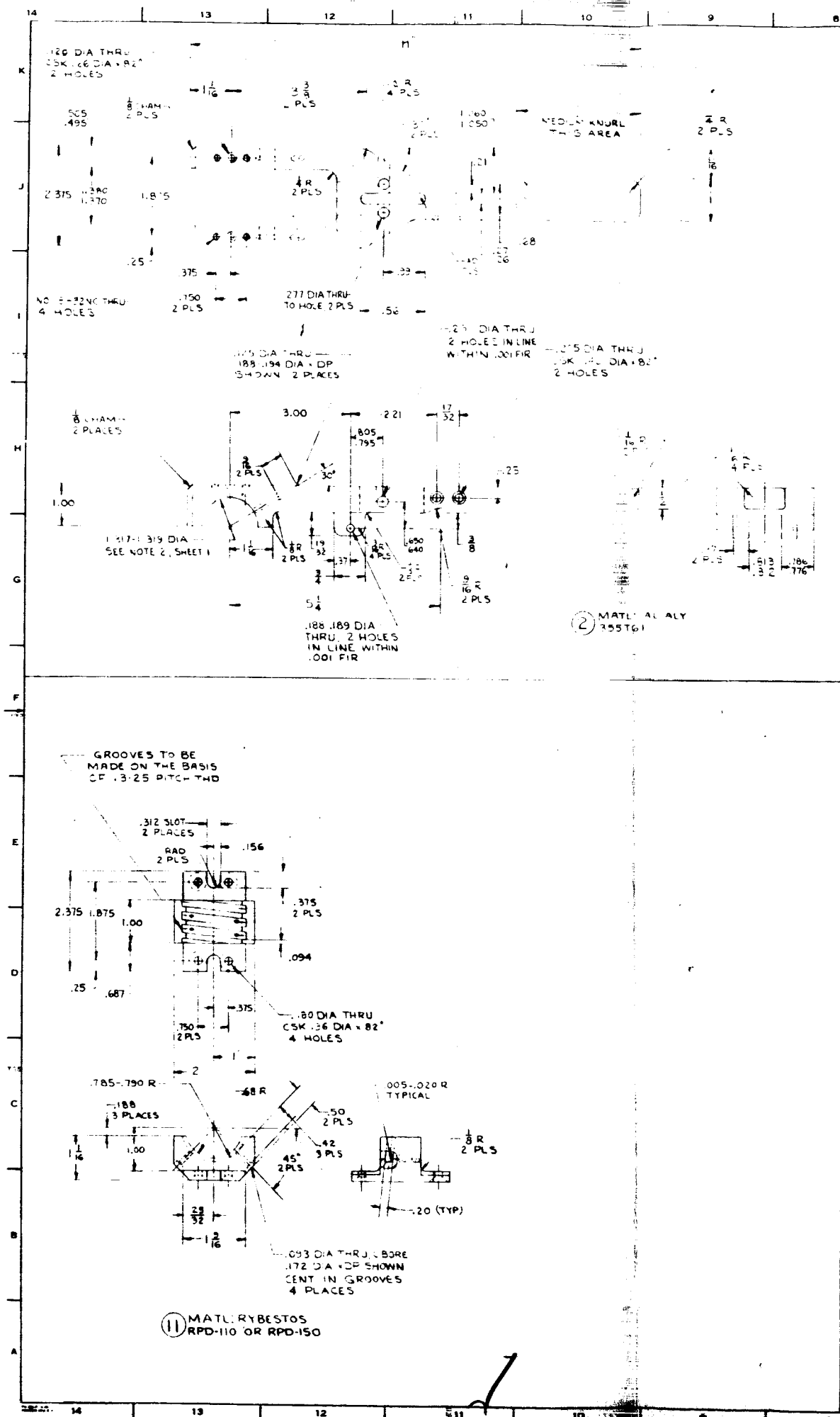
1. CONV PIN
2. CONV PIN
3. CONV PIN
4. CONV PIN
5. CONV PIN
6. CONV PIN
7. CONV PIN
8. CONV PIN
9. CONV PIN
10. CONV PIN
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97. CONV PIN
98. CONV PIN
99. CONV PIN
100. CONV PIN

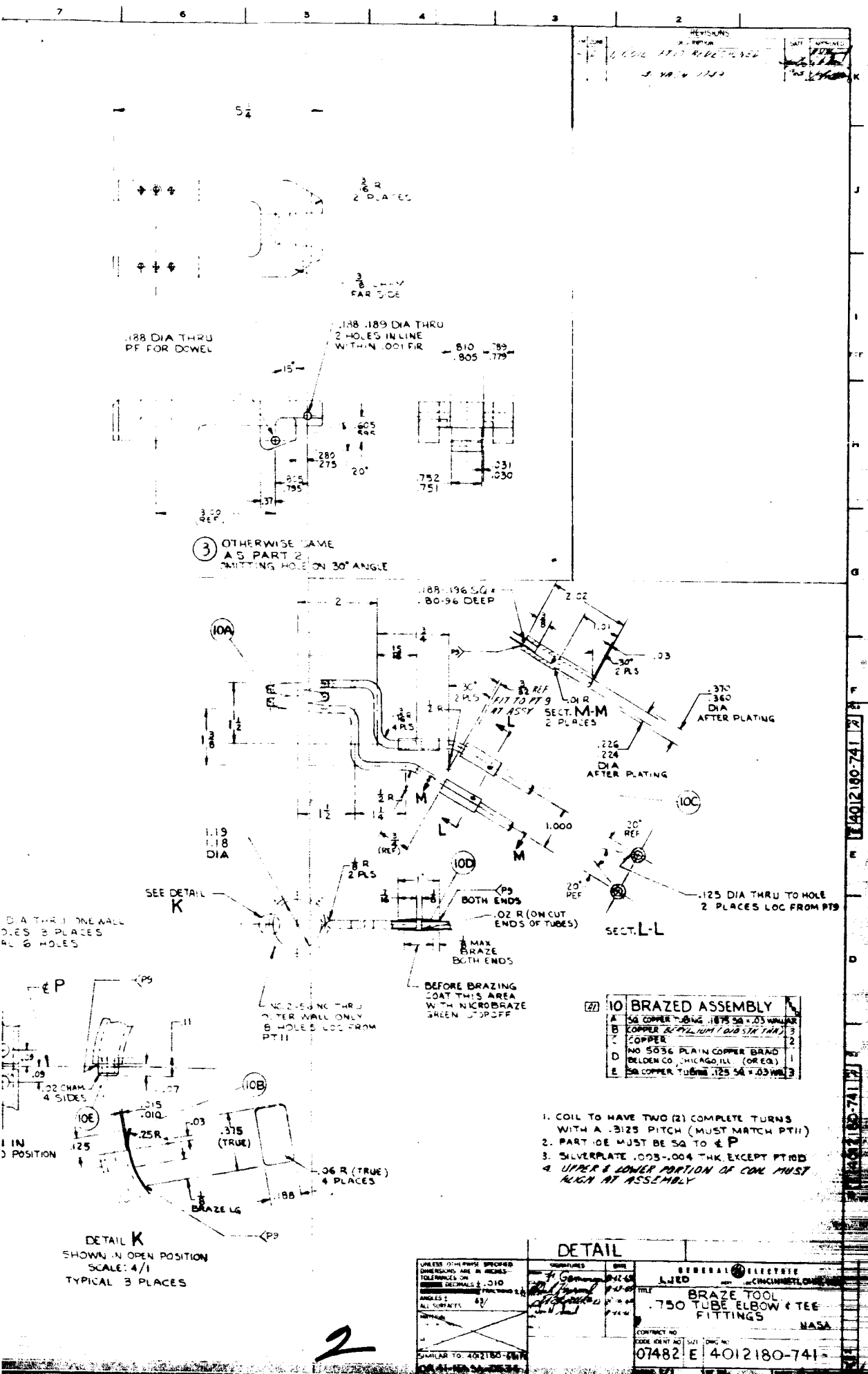
| | | | | | | | |
|-------------------------------|--|---------------------------------|--|----------------|--|---|--|
| SPECIFIED MATERIALS Q-3 | | SIGNATURE <i>[Signature]</i> | | DATE 7-1-63 | | FEDERAL ELECTRIC INC. 10000 CLEVELAND, OH 44130 TITLE BRAZE TOOL 750 TUBE ELBOW & TEE FITTINGS | |
| CONTRACT NO. | | SOURCE AGENT NO. | | DATE | | (DRAW NO) 47482 E 406180-741 | |

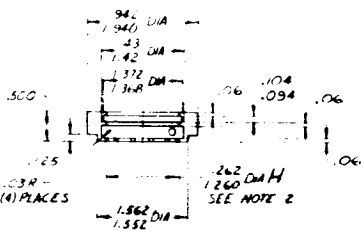
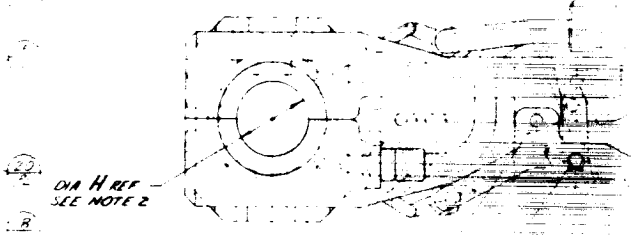
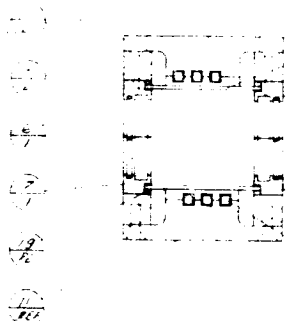
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE: FRACTIONS DECIMALS
FRACTIONS DECIMALS
ANGLES ± °
ALL SURFACES: *63*

NET WEIGHT

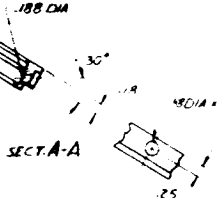
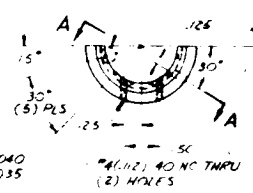
SHALAS TO





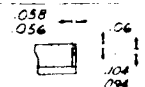


SEE DETAIL B



DETAIL B
TYP (6) PLACES
SCALE 4/1

ALL DIA TO BE .002 FIRM
WITHIN .002 FIRM



SECT. CC
TYP BOTH SIDES

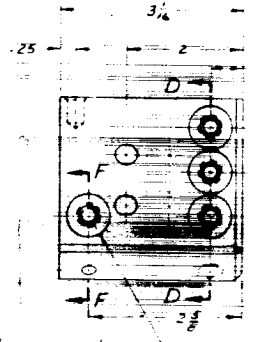


SECT. CC
TYP BOTH SIDES



(7) OTHERWISE SAME AS PT 5

(8) SAME AS PT 7 EXCEPT
OPPOSITE HAND



DIA .002 FIRM
SEE SECT. D & E

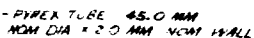
SCALE AS
SHOWN

SECT. E-E



SURF. R TO BE FLAT WITHIN .002 FIRM

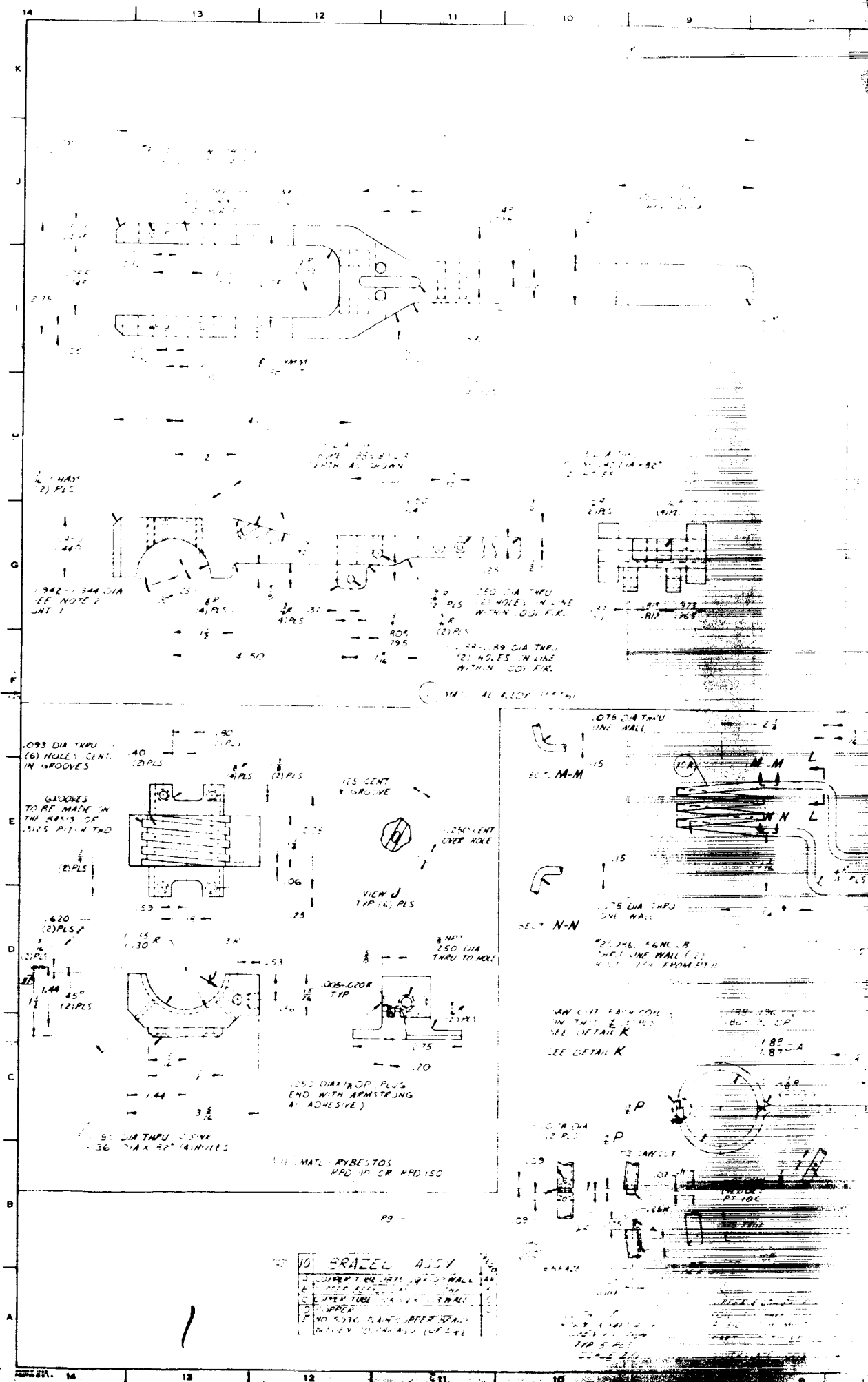
— 212 —

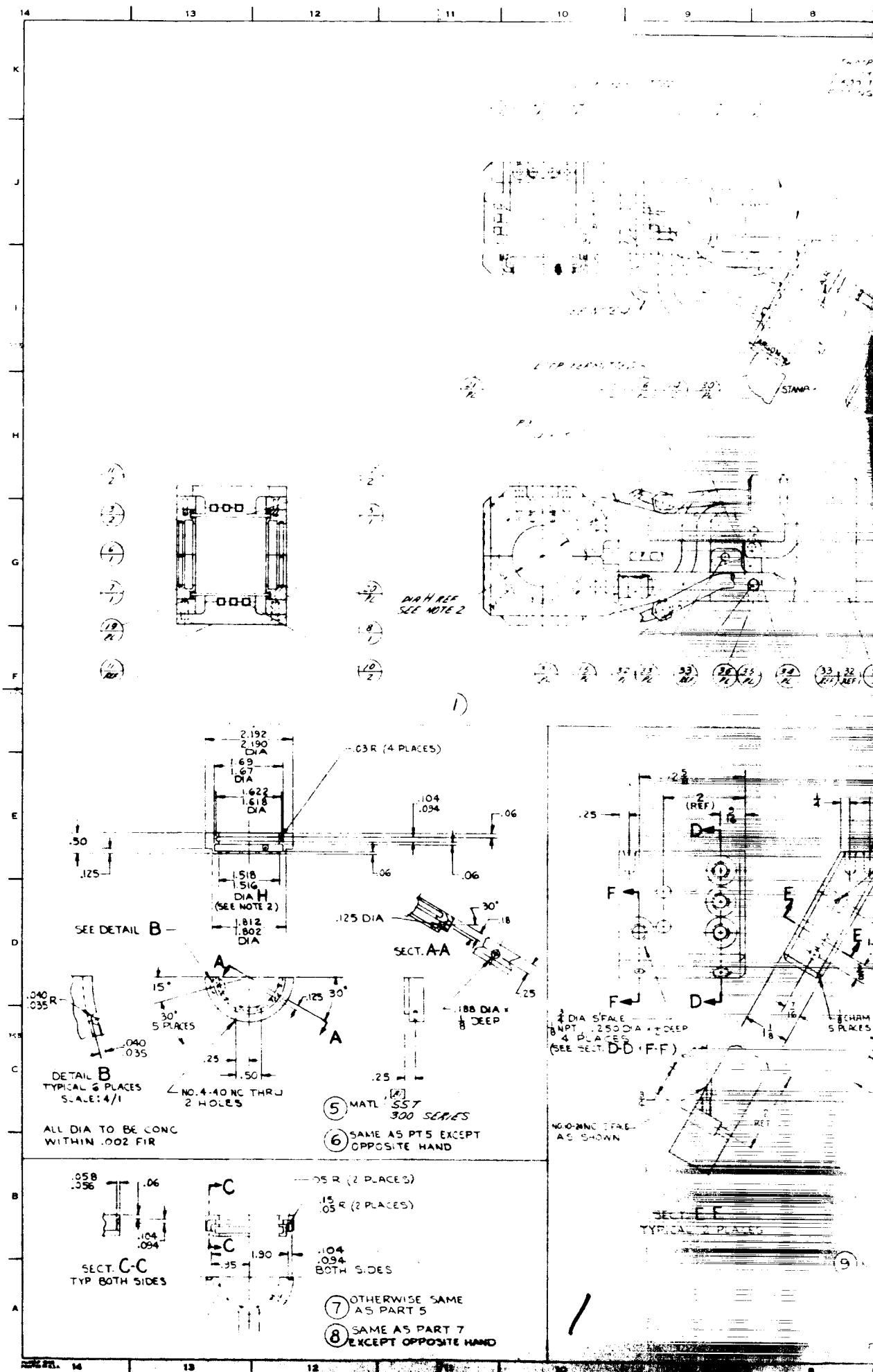


- | | | | |
|----|----------------------|----|--|
| 1 | SEE NOTE 7 | 37 | STORAGE CONTAINER (TO SUIT) |
| 2 | 1" DIA. | 38 | SET SCALP (FLAT POINT) (NO. 4 CROSS SECT) |
| 3 | 1" GROOVY PIN | 39 | INSERT NO. 5 1" DIA. x 1/2 |
| 4 | | 40 | DOWN 3/4" DIA. x 1/2 LG. |
| 5 | | 41 | DOWN 3/4" DIA. x 1/2 LG. |
| 6 | SSI 300 SERIES | 42 | SCAPER STIGAL 301A - 037A |
| 7 | THREE TURN | 43 | NO. 10 UNWIN (PLY) 4" DIA. TUBE TO UNWIN |
| 8 | BRONZE | 44 | WIRE CLOAK SC (NO. 4) |
| 9 | | 45 | SET SCALP (FLAT POINT) (NO. 4 CROSS SECT) |
| 10 | AND | 46 | CONNECTOR NO. 12 |
| 11 | GROOVY PIN | 47 | INSERT NO. 10 1" DIA. x 1/2 |
| 12 | THREE (OF 6) | 48 | FLAT HD SCREW NO. 2 1/2" DIA. x 1/2 LG. |
| 13 | | 49 | FLAT HD SCREW NO. 2 1/2" DIA. x 1/2 LG. |
| 14 | | 50 | FLAT HD SCREW NO. 2 1/2" DIA. x 1/2 LG. |
| 15 | | 51 | FLAT HD SCREW NO. 2 1/2" DIA. x 1/2 LG. |
| 16 | | 52 | FLAT HD SCREW NO. 2 1/2" DIA. x 1/2 LG. |
| 17 | SEE NOTE 6 | 53 | 0 RING 070 200 CROSS SECT |
| 18 | SEE NOTE 6 | 54 | 0 RING 070 200 CROSS SECT |
| 19 | SEE NOTE 5 | 55 | QUAD RING 103 CROSS SECT |
| 20 | POLYETHYLENE | 56 | TUBING 3" ID. 0.02 WALL - LCTS SUIT (BLUE) |
| 21 | POLYETHYLENE | 57 | TUBING 3" ID. 0.02 WALL - LCTS SUIT (BLUE) |
| 22 | POLYETHYLENE | 58 | TUBING 3" ID. 0.02 WALL - LCTS SUIT (BLUE) |
| 23 | 1" DIA. POLYETHYLENE | 59 | TUBING 3" ID. 0.02 WALL - LCTS SUIT (BLUE) |
| 24 | 4" DIA. | 60 | RING |
| 25 | 4" DIA. | 61 | TUBE |
| 26 | 4" DIA. | 62 | RACE JACKET HALF |
| 27 | 4" DIA. | 63 | CUL BLOCK |
| 28 | 4" DIA. | 64 | COIL |
| 29 | 4" DIA. | 65 | BLOCK |
| 30 | 4" DIA. | 66 | BLOCKING HALF |
| 31 | 4" DIA. | 67 | BLOCKING HALF |
| 32 | 4" DIA. | 68 | BLOCKING HALF |
| 33 | 4" DIA. | 69 | BLOCKING HALF |
| 34 | 4" DIA. | 70 | RAW TAPER |
| 35 | 4" DIA. | 71 | RODY |
| 36 | 4" DIA. | 72 | ASSEMBLY |

TYPE ASSY & DETAIL

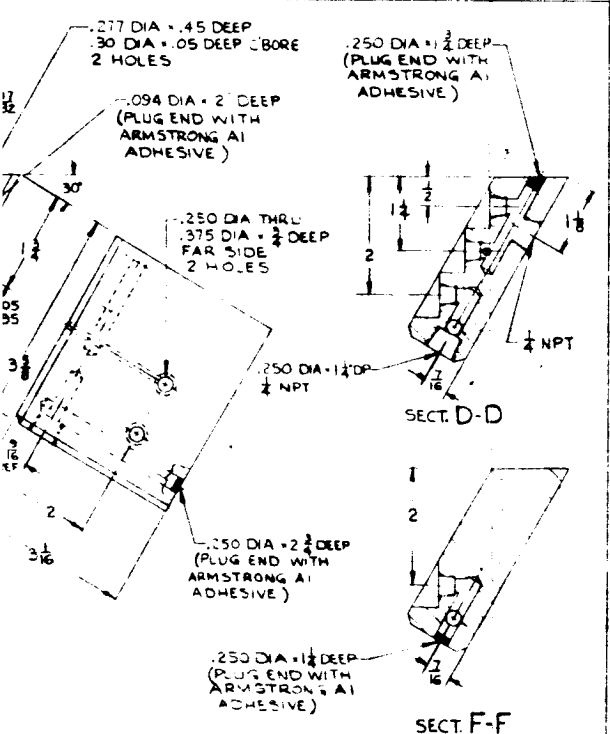
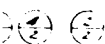
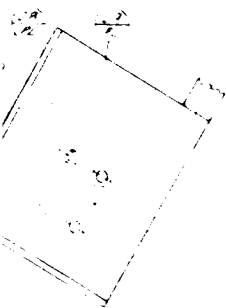
[illegible]





27

REVISIONS
ON 10/1/80
2. 11. CNT 2 REV 50
1. 11. 743
2. 11. 743
3. 11. 743
4. 11. 743
5. 11. 743



TL: TEXTOLITE

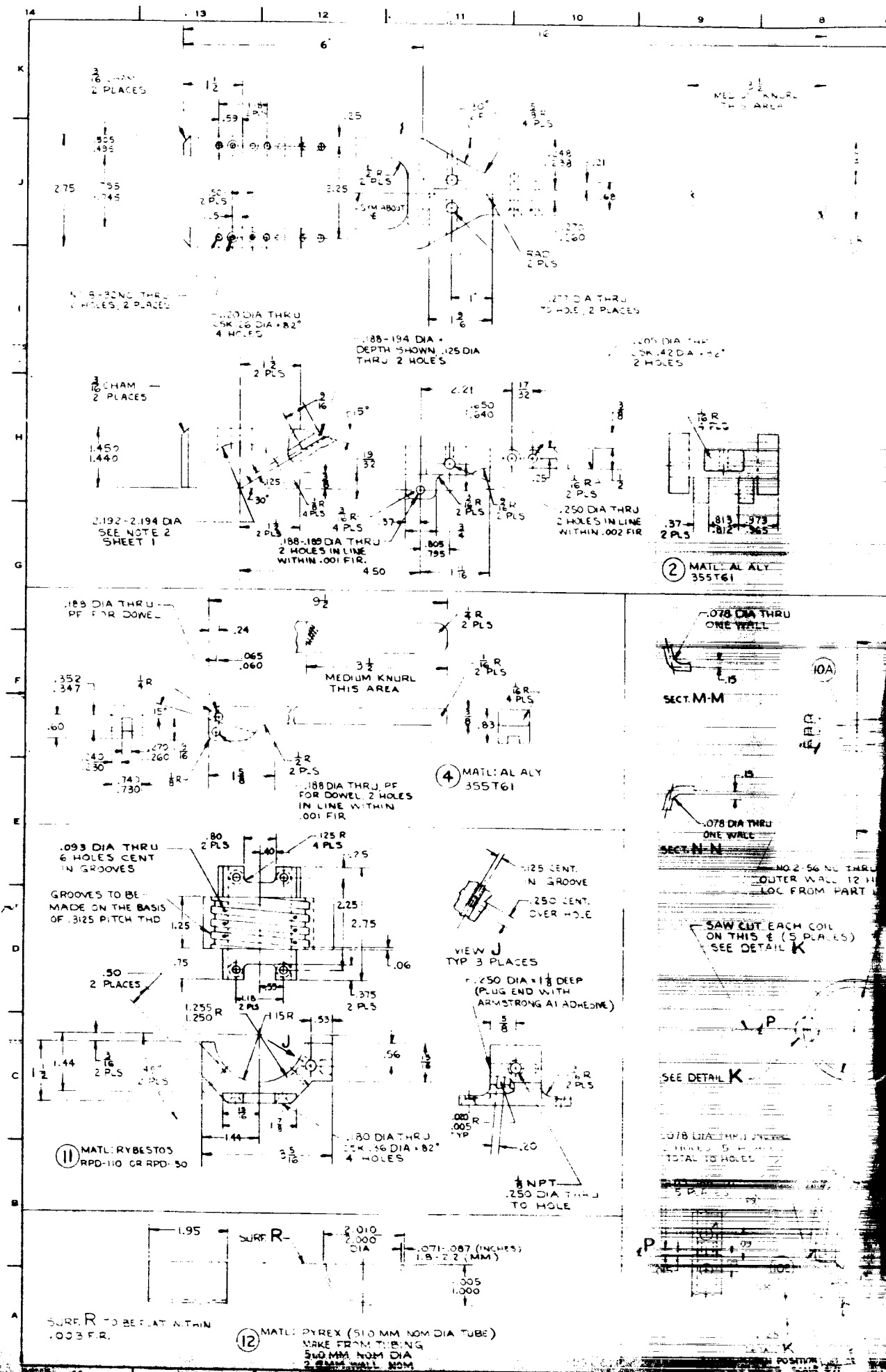
7. PROVIDE ARREST IN STORAGE CONTAINER FOR SIX SPARE PURGE JACKET SETS (PART 12) MARK CONTAINER WITH "BRAZE TAP FOR 1.500 TUBE ELBOW (TEE FITTINGS)"
8. O-RING VNON A OR B SERIES 2.050 .070 DIA CROSS SECTION, LENGTH TO SUIT PARKER SEAL CO. BOND WITH PLACE WITH GE SILICONE NO. 534004, PREPARE O-RING GROOVE FOR BONDING WITH GE TRANSLUCENT SILICONE RUBBER CLEAR SEAL GENERAL ELECTRIC PRODUCT DEPT
9. QUAD RING SEGMENT .103 CROSS SECTION, LENGTH TO SUIT "MINNESOTA RUBBER GASKET CO."
10. INSULATE EXPOSED AREA OF COIL PART 10, WITH "SCOTCH" ELECTRIC TAPE NO. 27 "MINNESOTA MINING & MFG CO
11. ANODIZE PART 2, 3, 4 PER AMS 2470 (RED)
12. DIA H, PARTS 5 & 7 & 8 TO BE IN LINE AT ASSEMBLY WITHIN .002 FIR
13. BREAK ALL SHARP EDGES

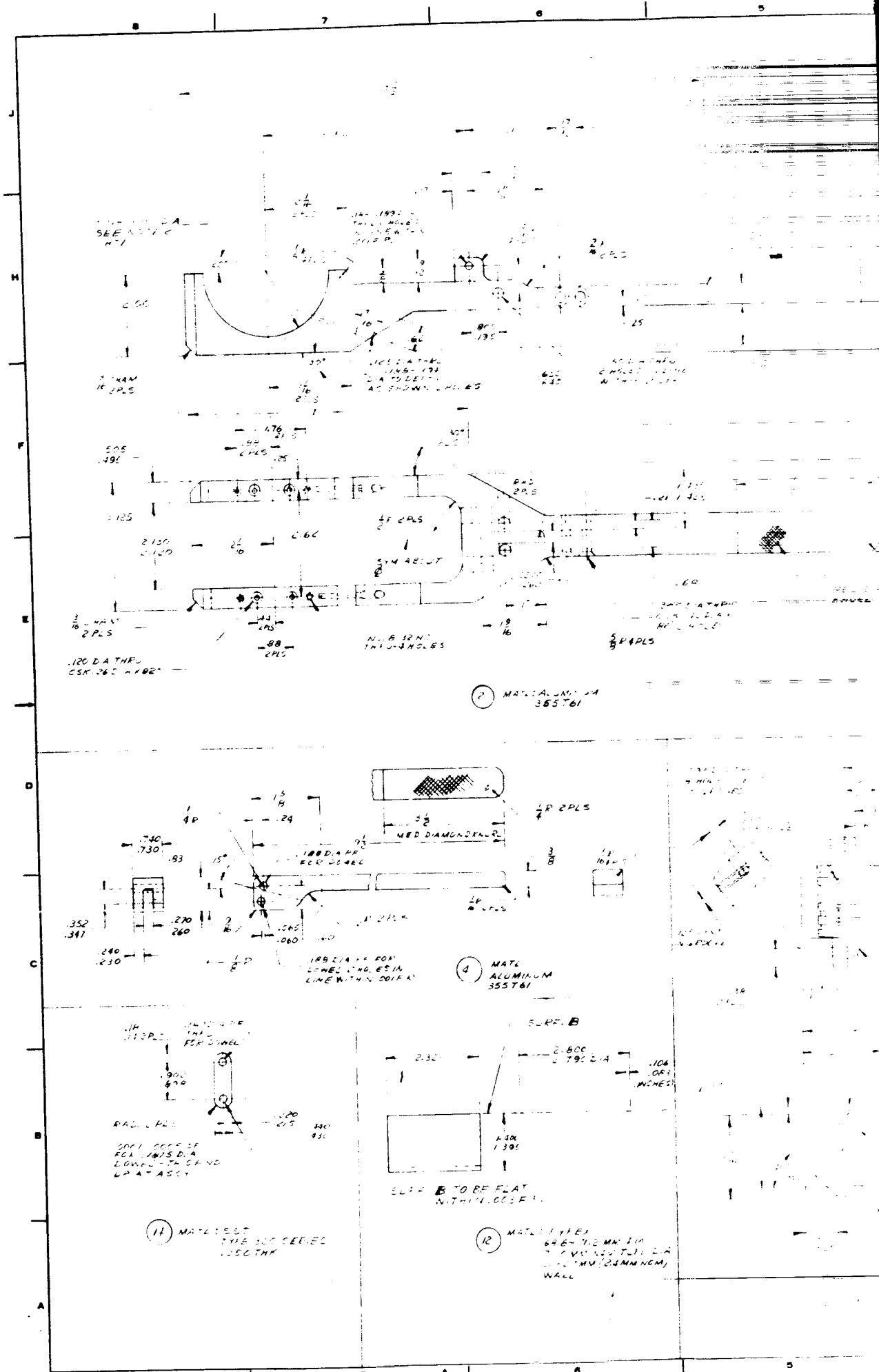
| | | | |
|----|----------------------|----|---|
| 1 | SEE NOTE 7 | 37 | STORAGE CONTAINER (TO SUIT) |
| 2 | COMM | 38 | SET SCREW (FLAT POINT) NO.10-24NC. 1/2 |
| 3 | | 39 | INSERT NO. 515024-12 |
| 4 | - GROOV PIN (OR EA) | 40 | CONEL 3/16 DIA. x 3/4 LG |
| 5 | | 41 | DOOR 3/16 DIA. x 1 1/2 LG |
| 6 | | 42 | SPACER 3/16 DIA. x 1 1/2 THK |
| 7 | SET TYPE 300 SCREW | 43 | HALF UNION (F/M) 1/16 DIA. TUB TO BWP |
| 8 | TUBE-TURN CO (OR EA) | 44 | STREET ELBOW (30°) SUIT (BRONZE) |
| 9 | | 45 | SET SCREW (FLAT POINT) NO.10-24NC. 1/2 LG |
| 10 | | 46 | CONNECTOR NO. A2800 |
| 11 | - ARO | 47 | INSERT NO. 19024-12 |
| 12 | - GROOV PIN (OR EA) | 48 | FLAT HD SCR NO.10-24NC. x 3/8 LG |
| 13 | | 49 | FITTING NO. 1/4-1/8-30182-4 |
| 14 | - PARKER JO (OR EA) | 50 | RD HD SCR NO.2-56NC. x 5/16 LG |
| 15 | | 51 | FLAT HD SCR NO.4-40NC. x 3/8 LG |
| 16 | | 52 | FLAT HD SCR NO.8-32NC. x 1/2 LG |
| 17 | | 53 | O-RING .070 DIA CROSS SECT |
| 18 | (SEE NOTE 6) | 54 | O-RING .070 DIA CROSS SECT |
| 19 | (SEE NOTE 6) | 55 | QUAD RING .103 CROSS SECT |
| 20 | (SEE NOTE 5) | 56 | TUBING 3/16 DIA. x .062 WALL x LG TO SUIT (NATURAL) |
| 21 | POLYETHYLENE | 57 | TUBING 3/16 DIA. x .062 WALL x LG TO SUIT (NATURAL) |
| 22 | POLYETHYLENE | 58 | TUBING 3/16 DIA. x .062 WALL x LG TO SUIT (NATURAL) |
| 23 | POLYETHYLENE | 59 | TUBING 3/16 DIA. x .062 WALL x LG TO SUIT (NATURAL) |
| 24 | COMM-POLYETHYLENE | 60 | TUBING 3/16 DIA. x .062 WALL x LG TO SUIT (NATURAL) |
| 25 | SHEET 2 | 61 | LINK |
| 26 | 2 | 62 | TUBE |
| 27 | 2 | 63 | PURGE JACKET HALF |
| 28 | 2 | 64 | COIL BLOCK |
| 29 | 2 | 65 | COIL |
| 30 | 2 | 66 | BLACK |
| 31 | 2 | 67 | BUSHING HALF |
| 32 | 2 | 68 | BUSHING HALF |
| 33 | 2 | 69 | BUSHING HALF |
| 34 | 2 | 70 | BUSHING HALF |
| 35 | 2 | 71 | HANDLE |
| 36 | 2 | 72 | JAW UPPER |
| 37 | 2 | 73 | BODY |
| 38 | SHEET 2 | 74 | ASSEMBLY |

ASSIGNED & DETAIL

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
TOLERANCES ON
DIMENSIONS ARE:
FRACTIONS
ALL SURFACES
FINISH

GENERAL ELECTRIC
BRAZE TOOL
TUBE, ELBOW & TEE
FITTINGS
NASA





| | | | | | |
|---|--|---|--|--|--|
| NAME OF ORIGIN (PRINTED) U.S. AIR MAIL SERVICE PHILADELPHIA, PA. PERMITS ALL PURPOSES DATE | | TYPE DETAILS DESCRIPTION NO. OF PKTS DATE TIME VALUE | | GENERAL ELECTRIC LARGE JET ENGINE PART CINCINNATI, OHIO, U.S.A. ERASE TOOL 2000 TUBS USED IN THE 5 TUBS | |
| FOR U.S. USE ONLY MAILING TO | | DATE COUNTRY ORIGIN NO. 07482 | | DATE NO. 1 | |

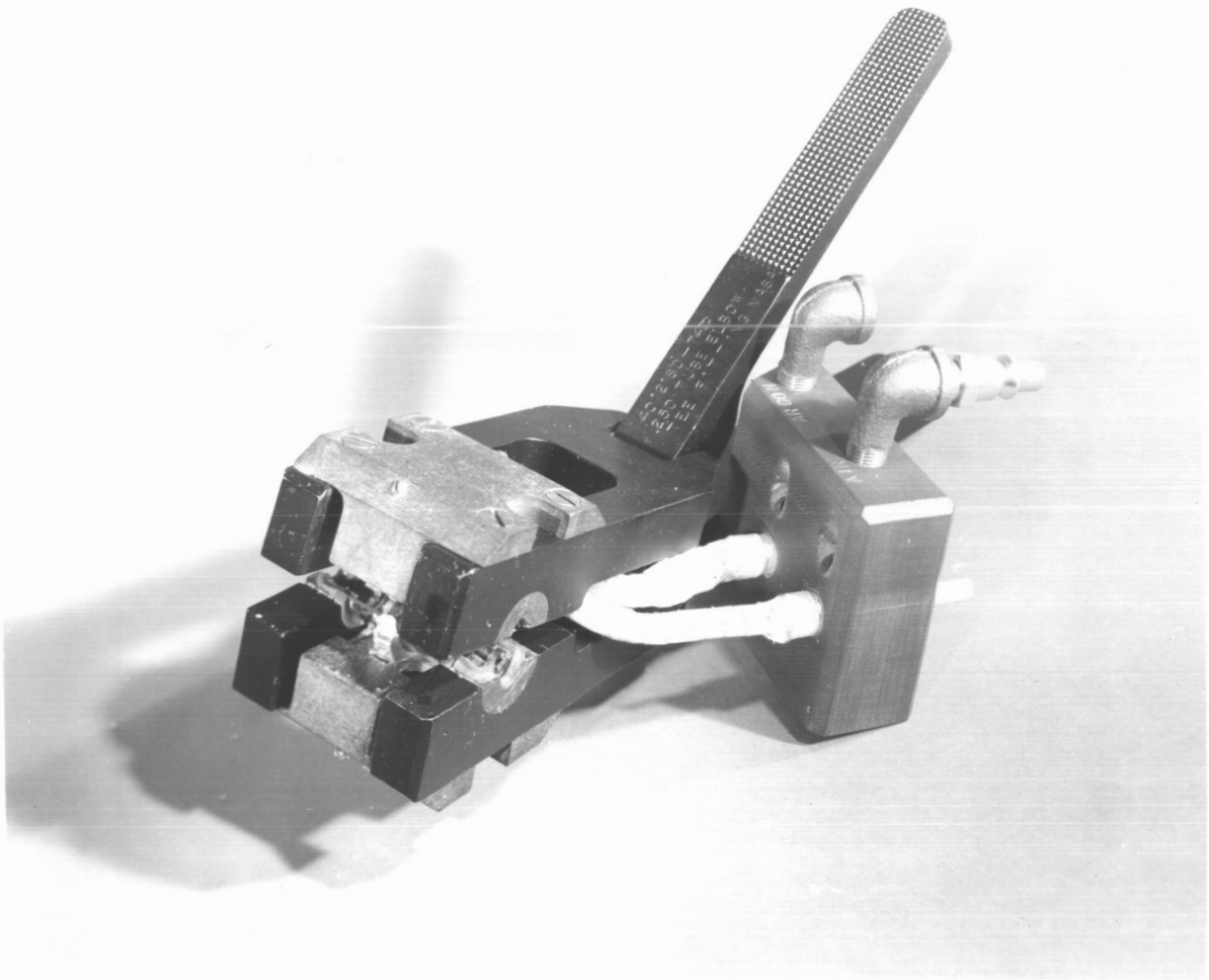


FIGURE 7

1/4" BRAZE TOOL FOR ELBOW & TEE FITTINGS

MO4761

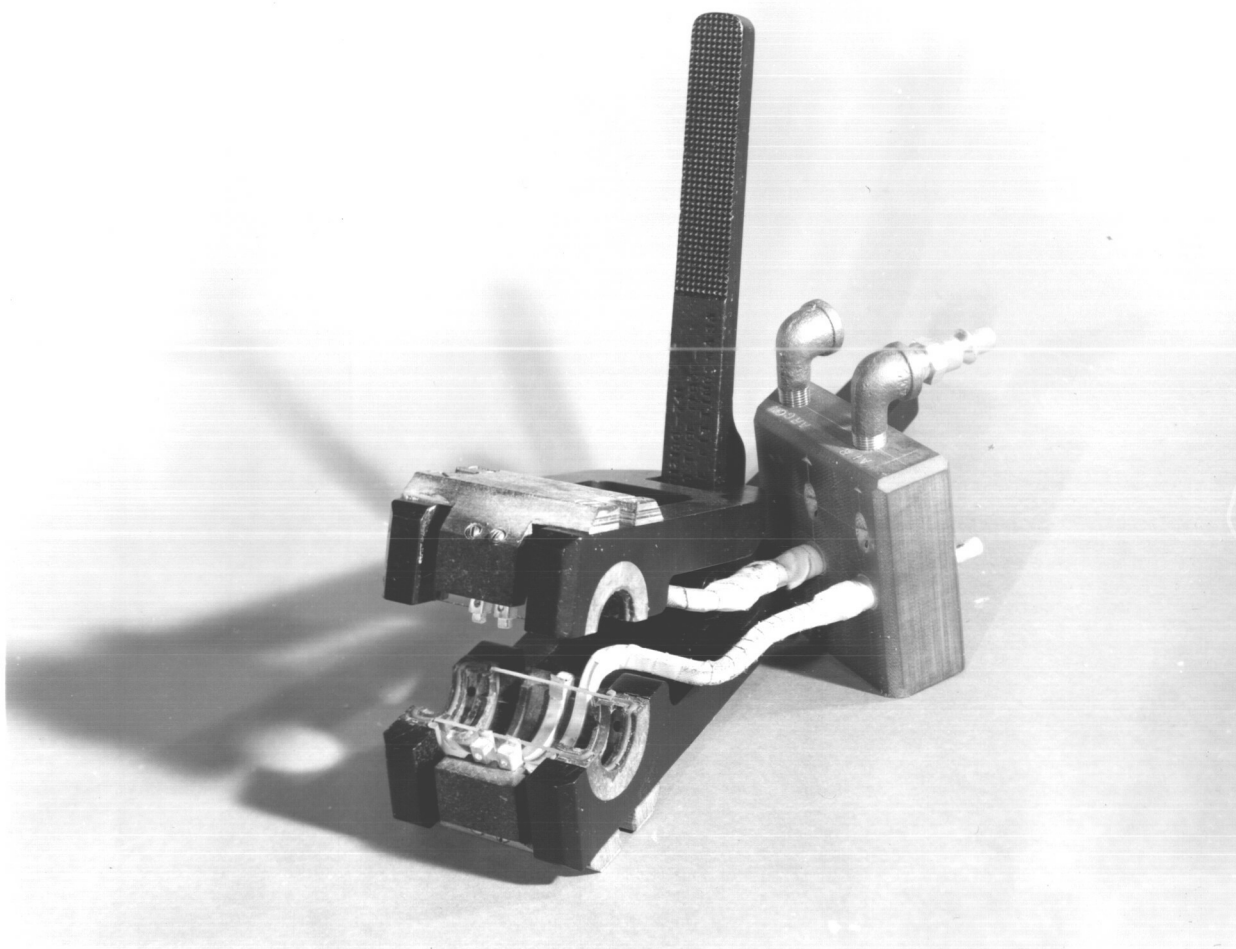


FIGURE 8

3/4" BRAZE TOOL FOR ELBOW & TEE FITTINGS

MO4761

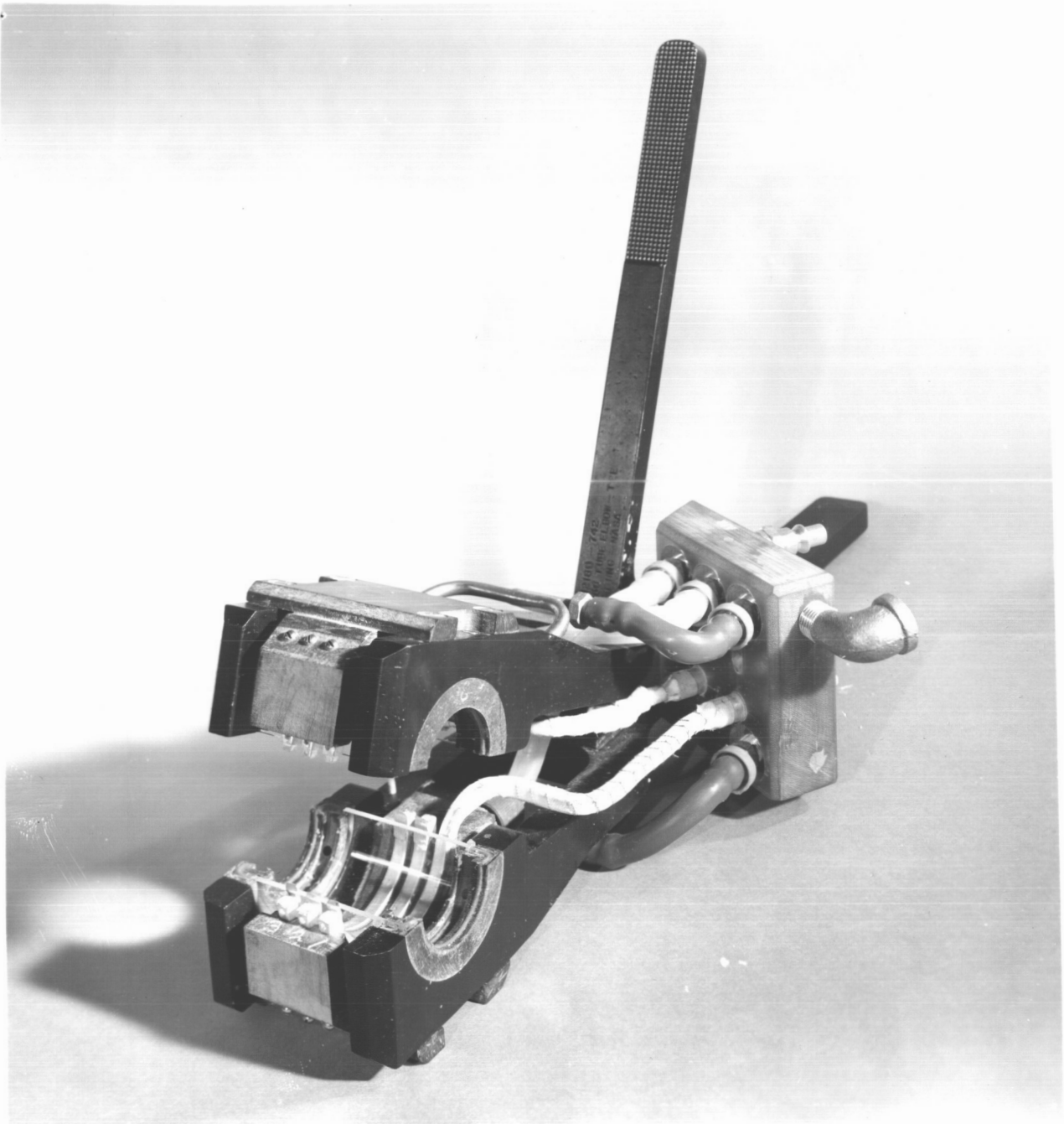


FIGURE 9

1 1/4" BRAZE TOOL FOR ELBCW & TEE FITTINGS

MO4761

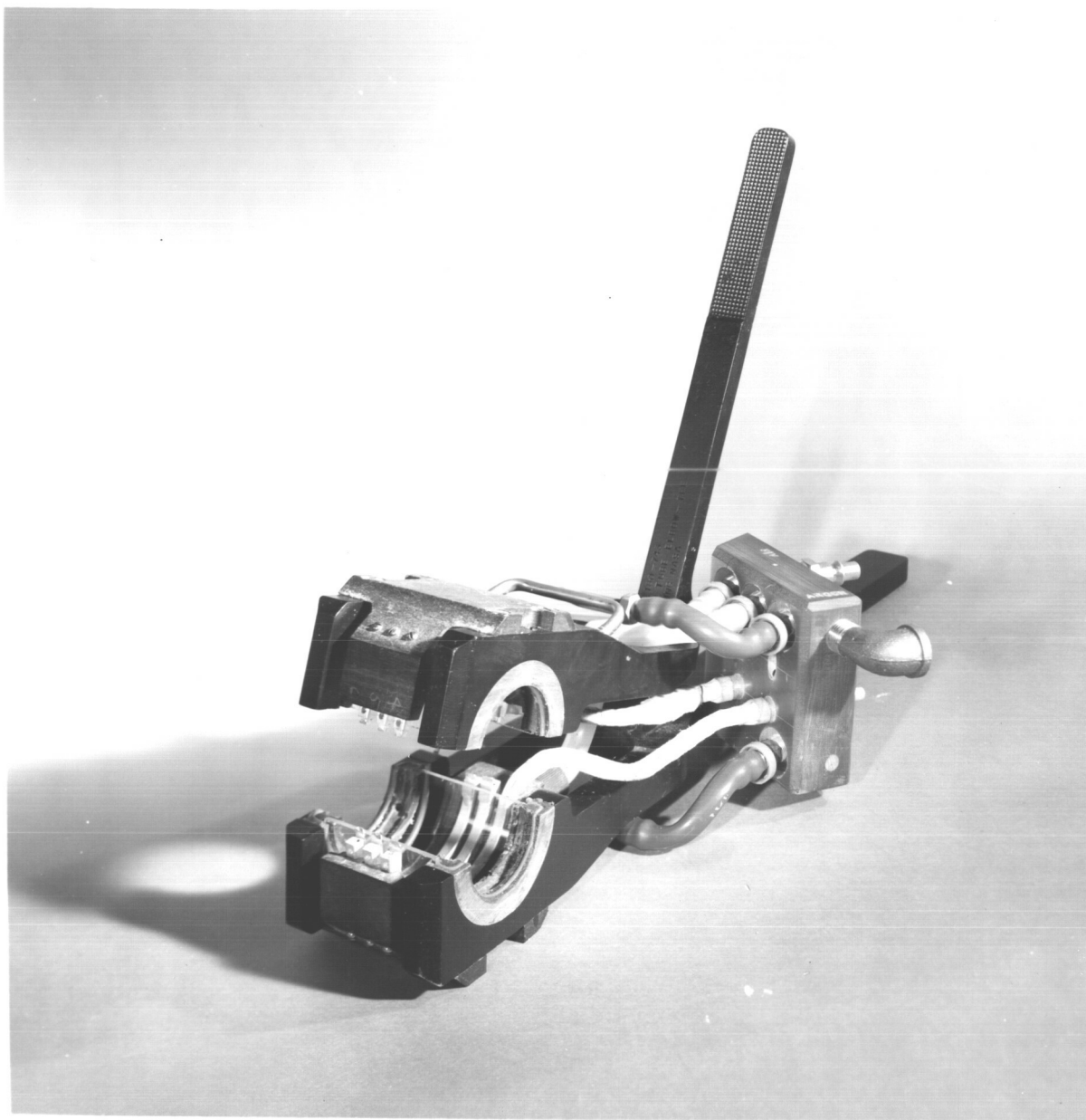


FIGURE 10

1 1/2" BRAZE TOOL FOR ELBOW & TEE FITTINGS

MO4761

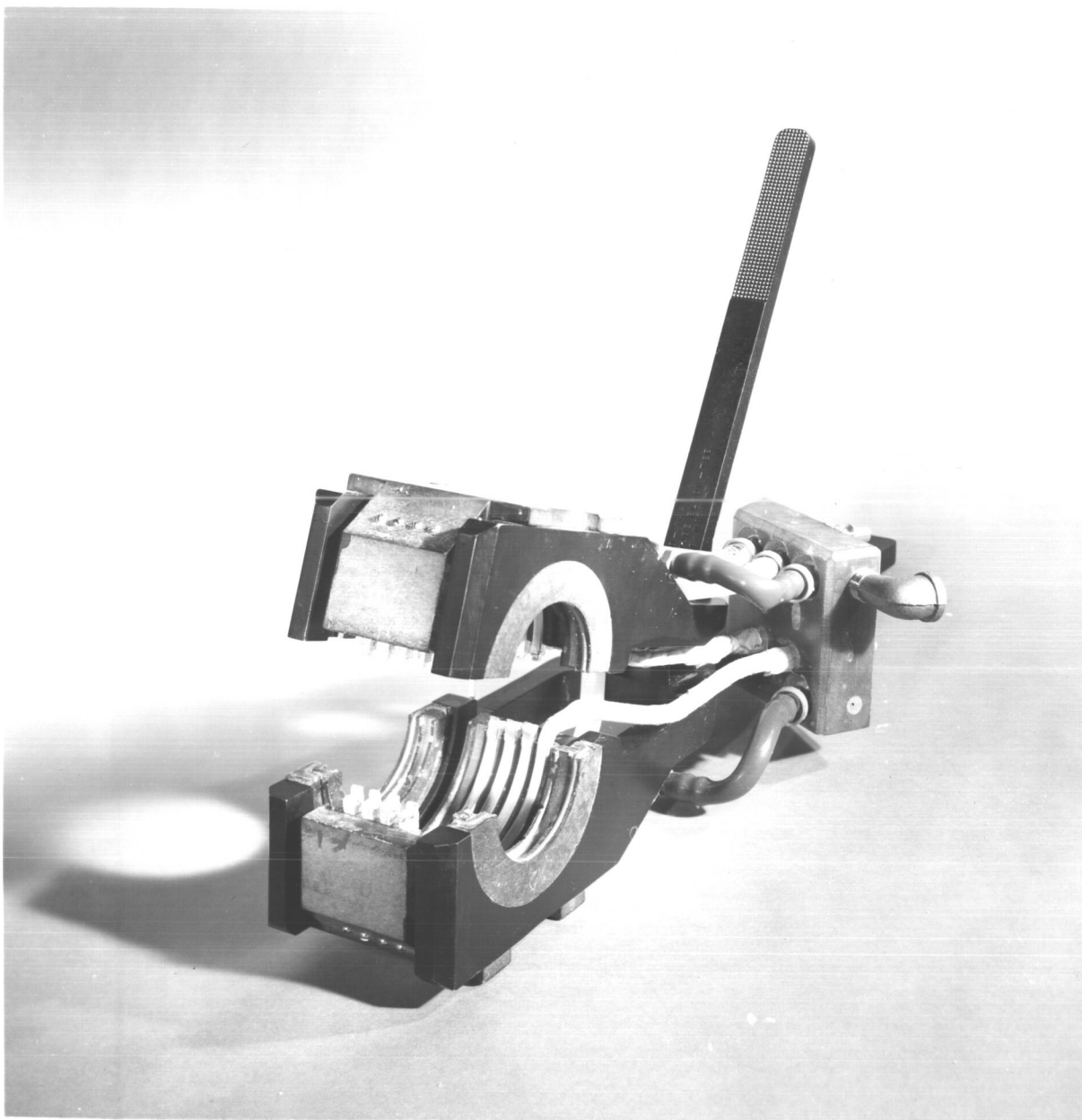


FIGURE 11

2" BRAZE TOOL FOR ELBOW & TEE FITTINGS

MO4761

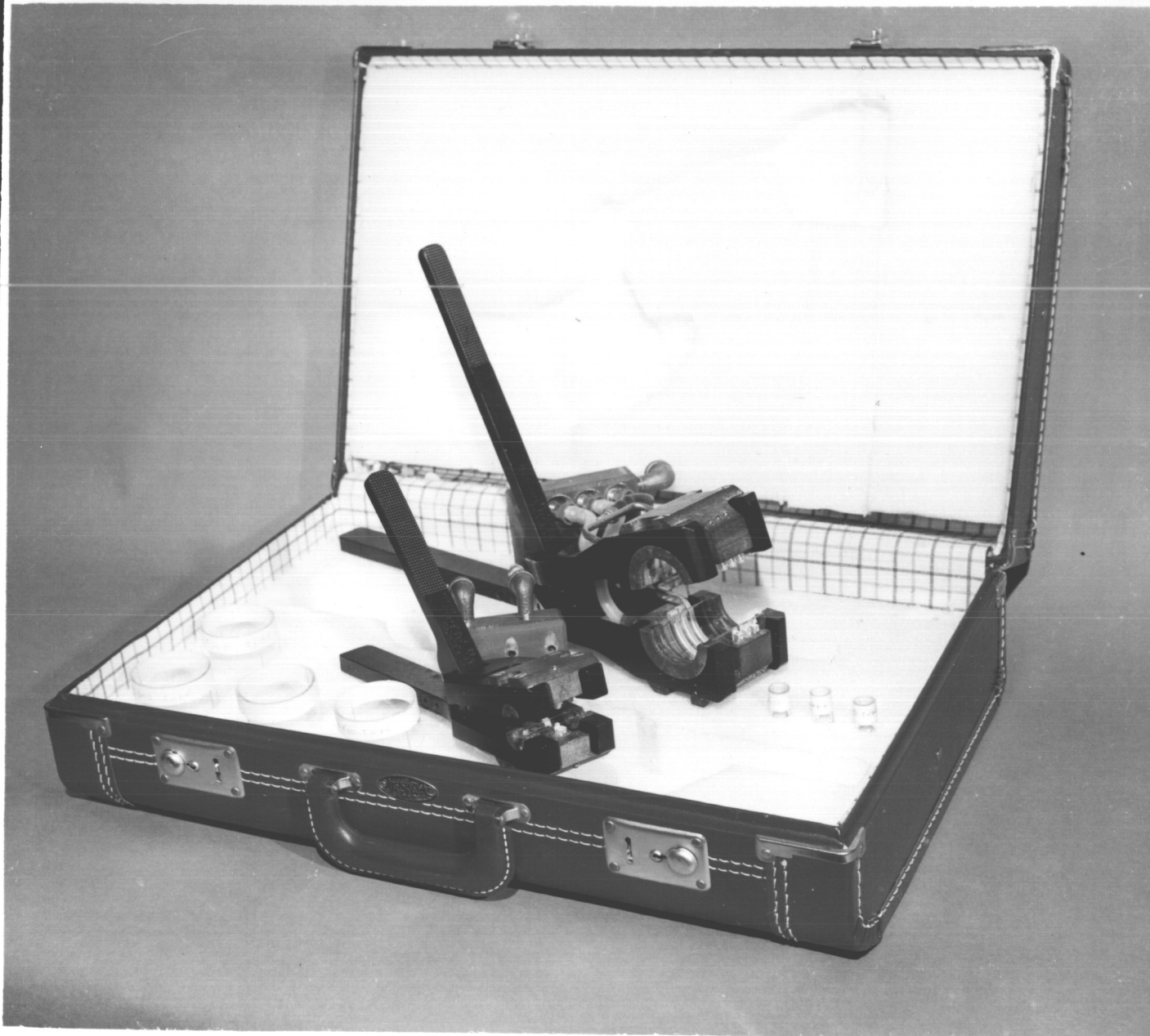


FIGURE 12

CARRYING CASE

MO4761



FIGURE 12A

CARRYING CASE

MO4761

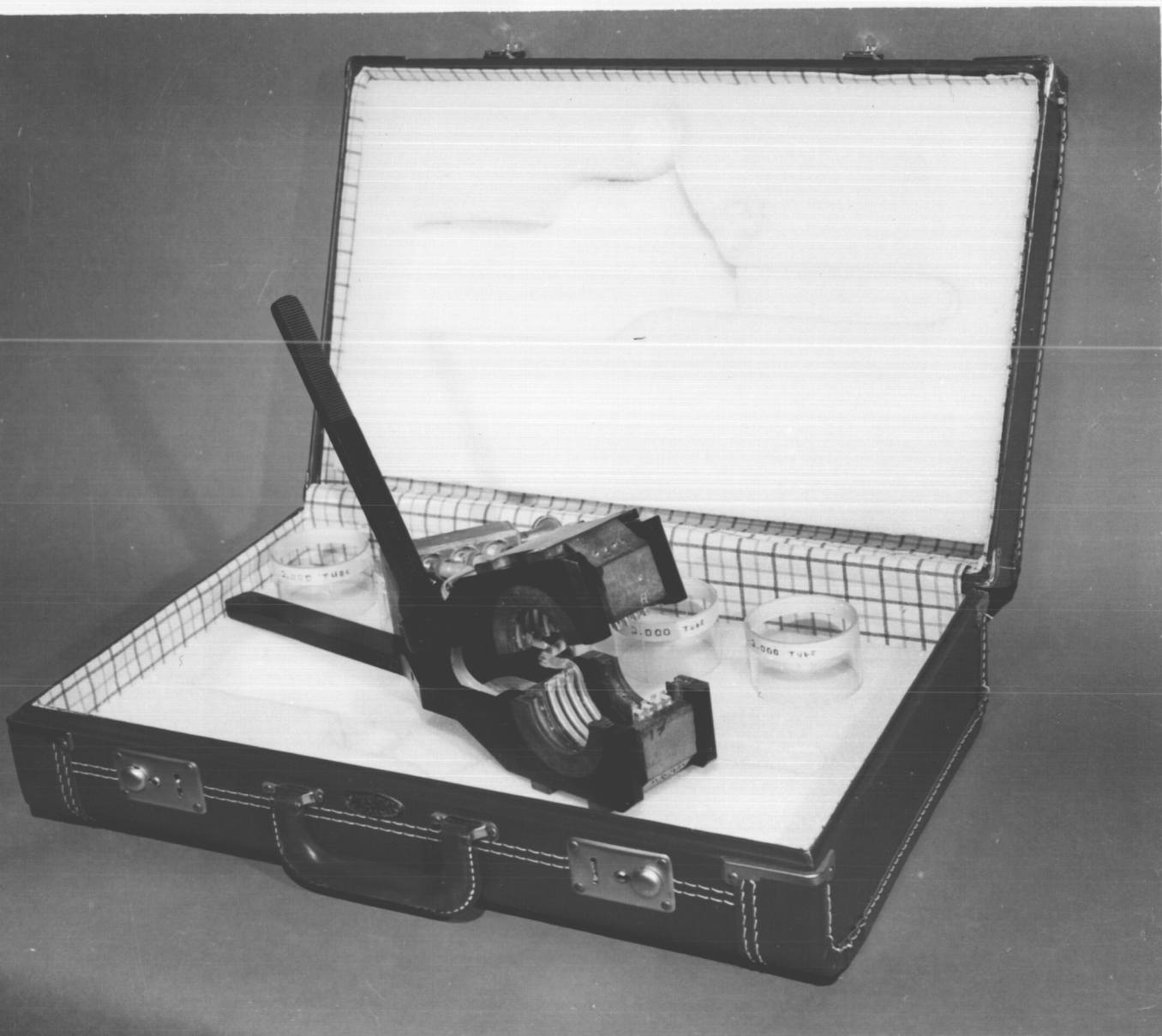


FIGURE 12B

CARRYING CASE

MO4761

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

TABLE III. Split Coil Data For Straight
Connectors

| <u>Tube Size</u> | <u>Coil I.D.</u> | <u>Coil Turns</u> | <u>Coil Pitch</u> |
|------------------|------------------|-------------------|-------------------|
| .250 | .60 .59 | 3 | .286 |
| .750 | 1.19 1.18 | 4 | .286 |
| 1.250 | 1.88 1.87 | 5 | .375 |
| 1.500 | 2.12 2.11 | 6 | .375 |
| 2.000 | 3.07 3.06 | 8 | .312 |
| 2.500 | 3.27 3.26 | 8 | .375 |

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

TABLE IV. Split Coil Data For Elbow And
Tee Type Fittings

| <u>Tube Size</u> | <u>Coil I.D.</u> | <u>Coil Turns</u> | <u>Coil Pitch</u> |
|------------------|------------------|-------------------|-------------------|
| .250 | .60 .59 | 1 | .375 |
| .750 | 1.19 1.18 | 2 | .3125 |
| 1.250 | 1.88 1.87 | 3 | .3125 |
| 1.500 | 2.12 2.11 | 3 | .3125 |
| 2.000 | 2.88 2.87 | 4 | .3125 |

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

┌ Debraze Tool ┐

The fitting must first be cut in half, then the debrazing tool is used to remove the remaining half coupling, elbow or tee type fitting. The removal of fittings are necessary when lines must be disconnected to replace a braze fitting, filters, or replace sections of tubing.

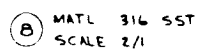
The debrazing fixture, Figure 13 is a semi-automatic tool which works in conjunction with its corresponding heating coil, Figure 14 and 14A. The coil itself is housed in a containing block which has guide sleeves for centering the coil to the fitting, an argon gas outlet that inserts into the tube and acts to catch the hot parted fitting when removed. The continuous wound heating coil for the debrazing fixture is used to remelt the braze alloy. This coil is made from soft copper tubing .187 x .030 wall with sufficient turns to overlap the brazed area by .070 minimum and the I.D. of the coil is at least .120 greater than the O.D. of the fitting.

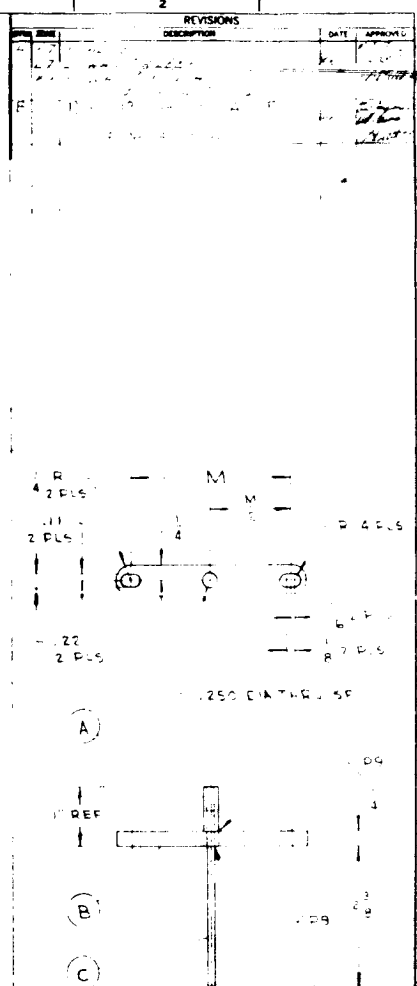
The other half of the debrazing fixture is air operated. An adjustable hardener split block sets next to the fitting to be removed. The extension to this block has teflon sleeves to prevent binding when this is moved forward by the striking arm. The tool itself is held to the tubing by an adjustable split brass sleeve. Prints 4012180-728 detail all heating units and prints, 4012180-731 thru 736 detail the debrazing fixture.

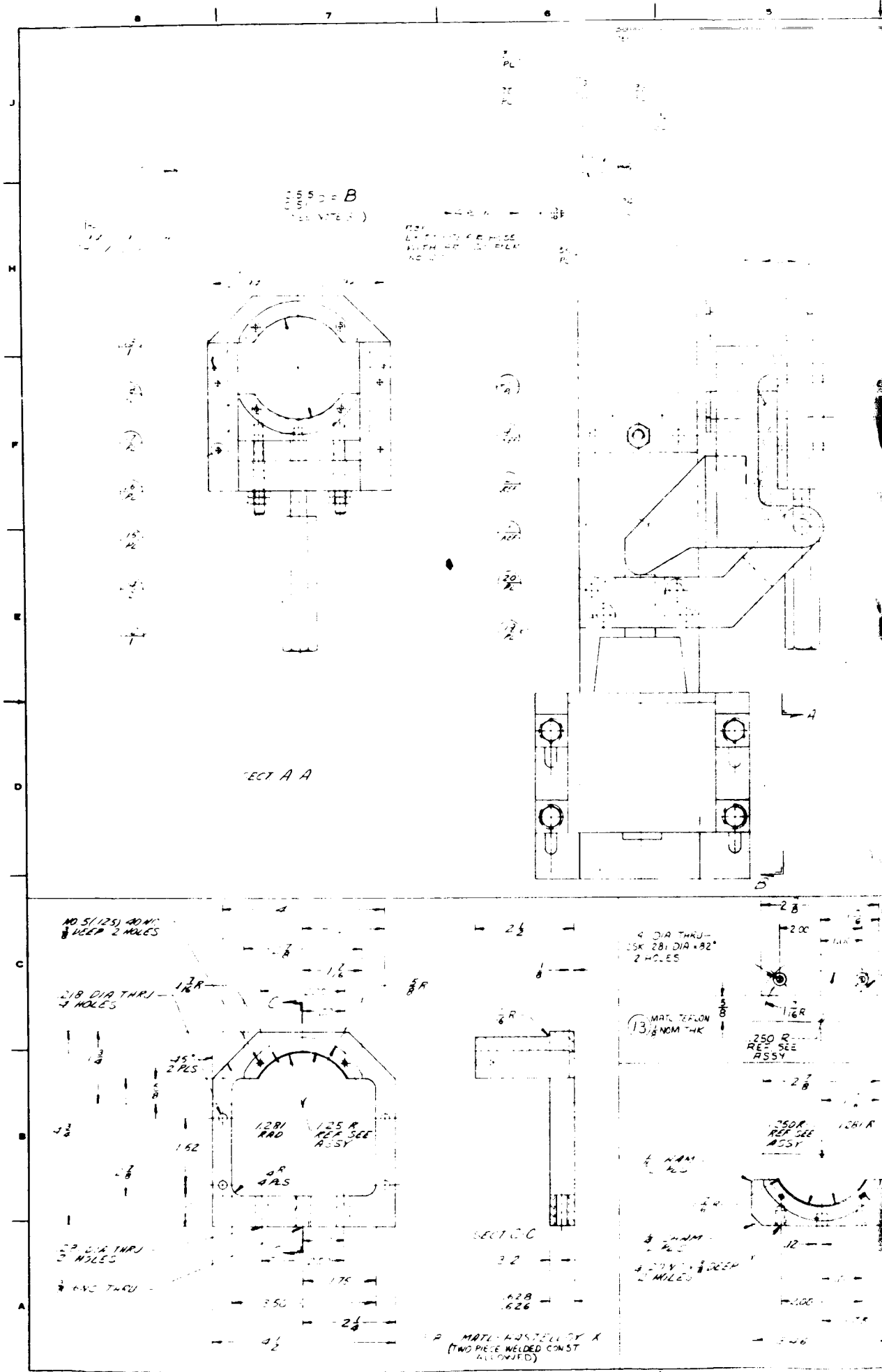
Sizing Tools

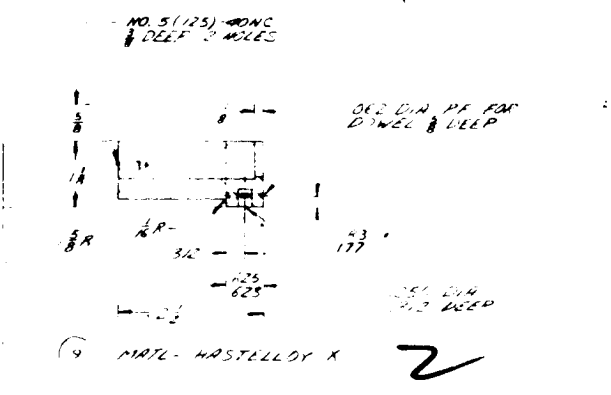
There are two methods of sizing tubing - expansion and reduction. Both methods were investigated during the initial braze program and reduction was chosen because closer tolerances could be achieved and it was a much simpler operation. Also, a more practical and compact tool could be designed for the reduction method. The tools designed, Figure 15, attach to a two-directional motor mounted on a table. Each sizing tool is interchangeable with the two-directional motor. Every sizing tool has a matching clamping block which slides on parallel bars and holds the tubing stationary during the sizing operation. Figures 16, 16A and 16B show three different sizing housings and matching clamping blocks. For details see print 4012180-729.

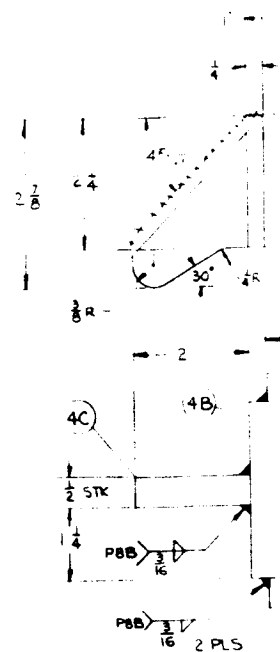
The design of the sizing tools for 1/4", 3/4", 1 1/4", 1 1/2" are all the same. Problems were encountered with the 2" and the 2 1/2" sizing tool, mainly a flaring condition on the end of the tube sized. Design of 2" and 2 1/2" sizing tool was altered to correct this.



[illegible]







| | |
|---|-----|
| A | HRS |
| B | HRS |
| C | HRS |

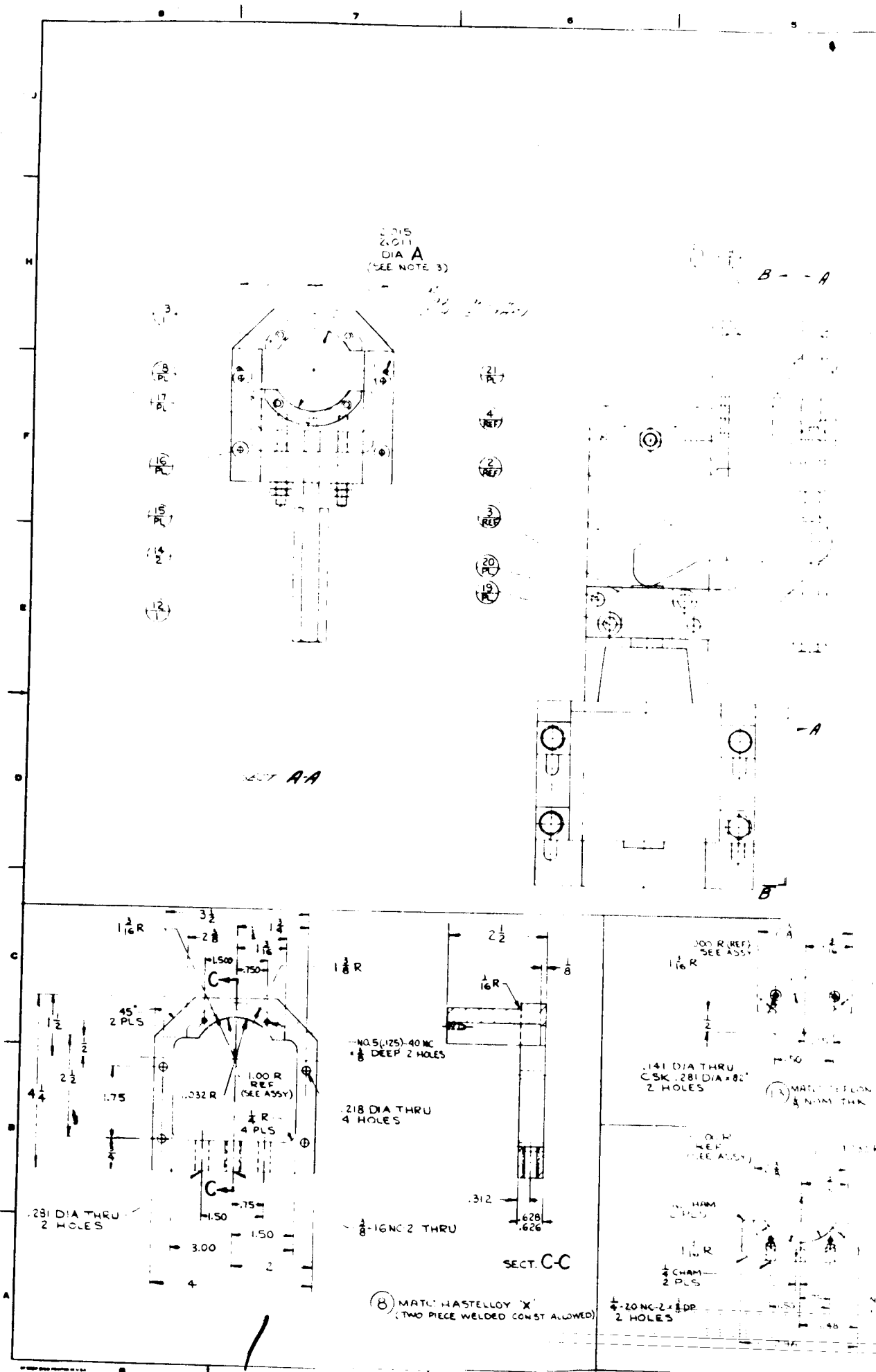
[illegible]

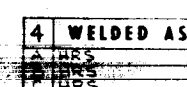
| | | |
|---|-----------|---|
| A | HRS | 1 |
| B | HRS | 1 |
| C | STL ANGLE | 2 |

[illegible]

A HRS
B BRASS (QUARTER HARD)

③ MATL: HRS
NOTE: MAY BE MADE FROM
TWO (2) PIECE CONST





Technical drawing of a mechanical part, likely a bracket or support, showing dimensions and assembly notes. The drawing includes a side view and a top view.

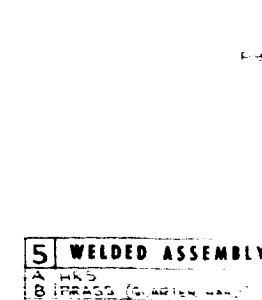
Dimensions:

- Overall width: 3
- Overall height: 1 1/2
- Top flange width: 1 1/2
- Top flange thickness: 1/8 APPROX BOTH SIDES
- Vertical distance from top flange to center of hole: 1 1/8
- Horizontal distance from left edge to center of hole: 1 1/2
- Horizontal distance between holes: 1 1/2
- Horizontal distance from right edge to center of hole: 1 1/2

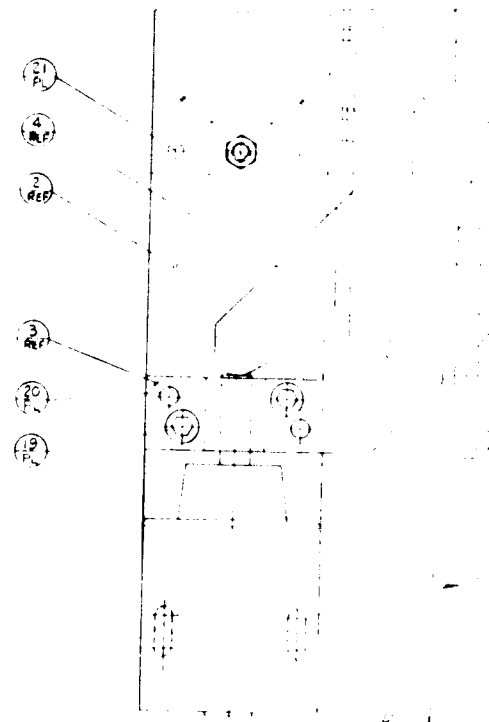
Assembly Notes:

- 2.50 DIA THRU PF FOR DOWEL
- 2 HOLES, LINE DRILL WITH PART 6
- THD 1/8" COBOR
- 1/8" DIA PT 6

5 WELDED ASSEMBLY
A HK5
B PRASS (GARDEN HAWK)



NOTE: MAY BE MADE FROM TWO (2) PIECE CONST



3 1/2

1 1/2

1 7/8

1.44

1.72

1.12 R

1 1/8 R

NO. 5 (125)-40 NC 3/8 DEEP, 2 HOLES

2 1/2

1/8

1/16 R

45°

2 PL5

3 1/2

2 1/8

1.875

1/2

150 R (REF) SEE ASSY

4 PL5

2.18 DIA THRU 4 HOLES

28.1 DIA THRU 2 HOLES

1.50

1.25

2.50

3

3/8-16 NC-2 THRU

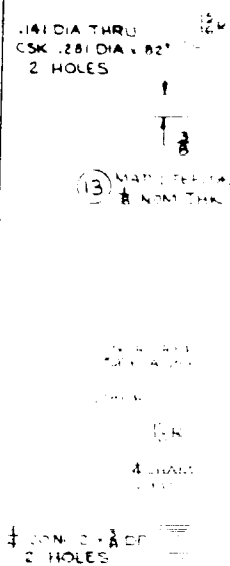
3/12

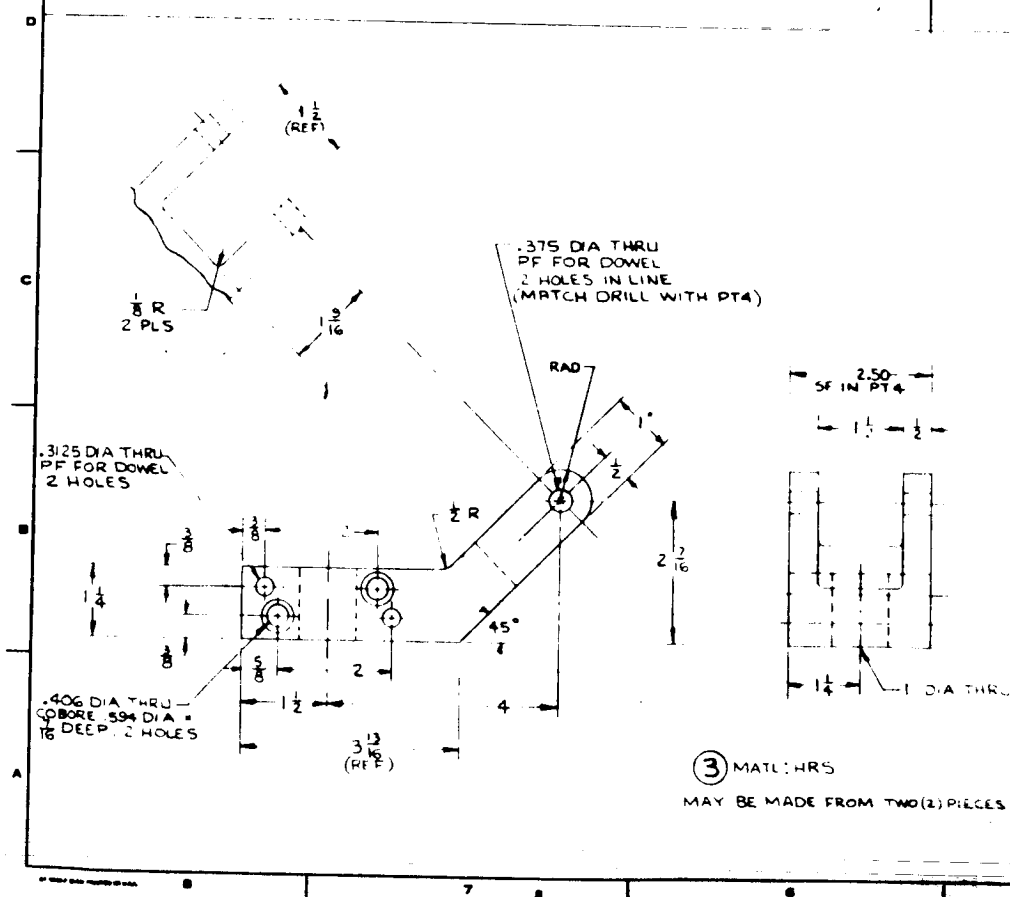
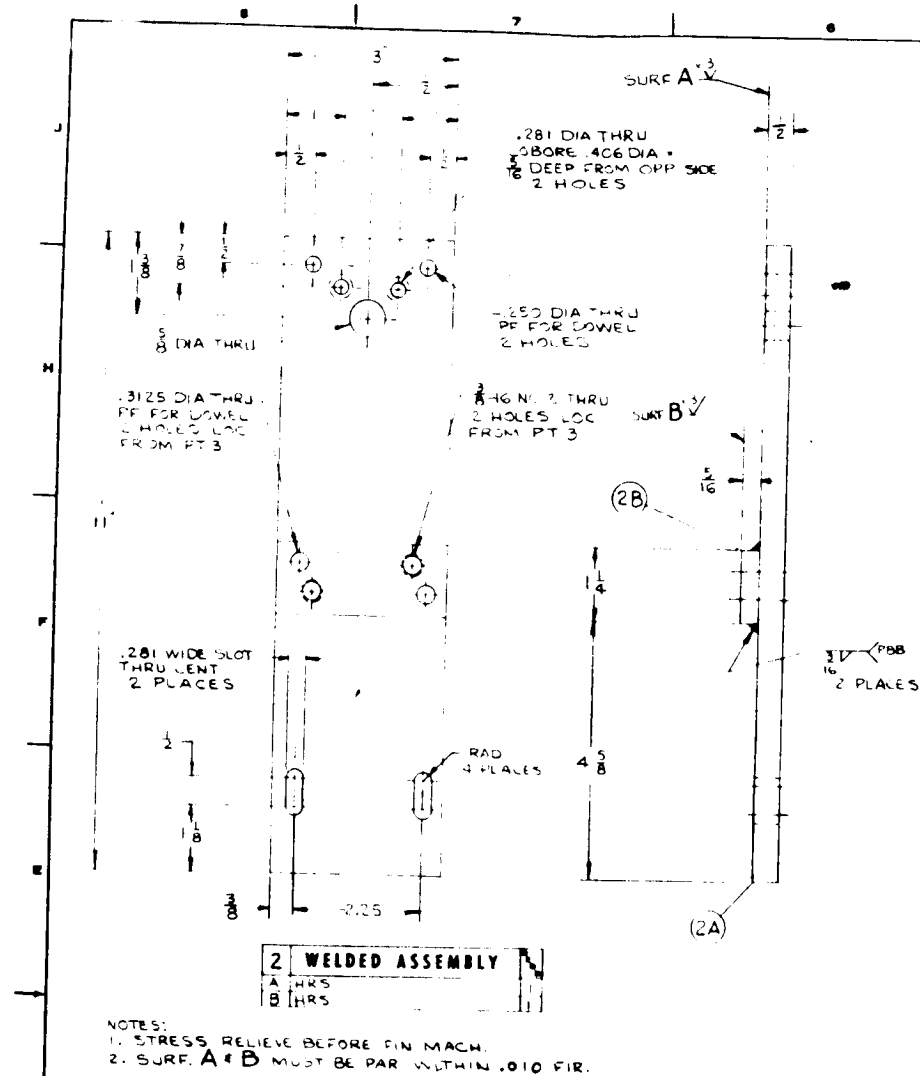
6.28

6.26

SECT. C-C

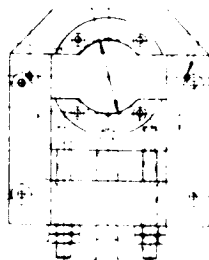
⑧ MATL: HASTELLOY 'X'
(TWO PIECE WELDED CONST ALLOWED)





| | |
|---|--|
| NORTH AMERICAN SCIENTIFIC EQUIPMENT CO. INC. 200 WEST CHICAGO ROAD #2 2-408 21 ALL COUNTRIES 123  | FEDERAL ELECTRIC 1000 N. BROAD ST. CHICAGO, ILL. U.S.A. DE BRAZE KNOCKOFF TOOL FOR 1½ O.D. TUBE  |
|---|--|

Seven small circular diagrams showing different stages of a cell cycle, labeled 1 through 7. The diagrams are arranged vertically. Diagram 1 shows a cell with a single nucleus. Diagram 2 shows a cell with a single nucleus and a small amount of cytoplasm. Diagram 3 shows a cell with a single nucleus and a small amount of cytoplasm. Diagram 4 shows a cell with a single nucleus and a small amount of cytoplasm. Diagram 5 shows a cell with a single nucleus and a small amount of cytoplasm. Diagram 6 shows a cell with a single nucleus and a small amount of cytoplasm. Diagram 7 shows a cell with a single nucleus and a small amount of cytoplasm.



1 2
4

5

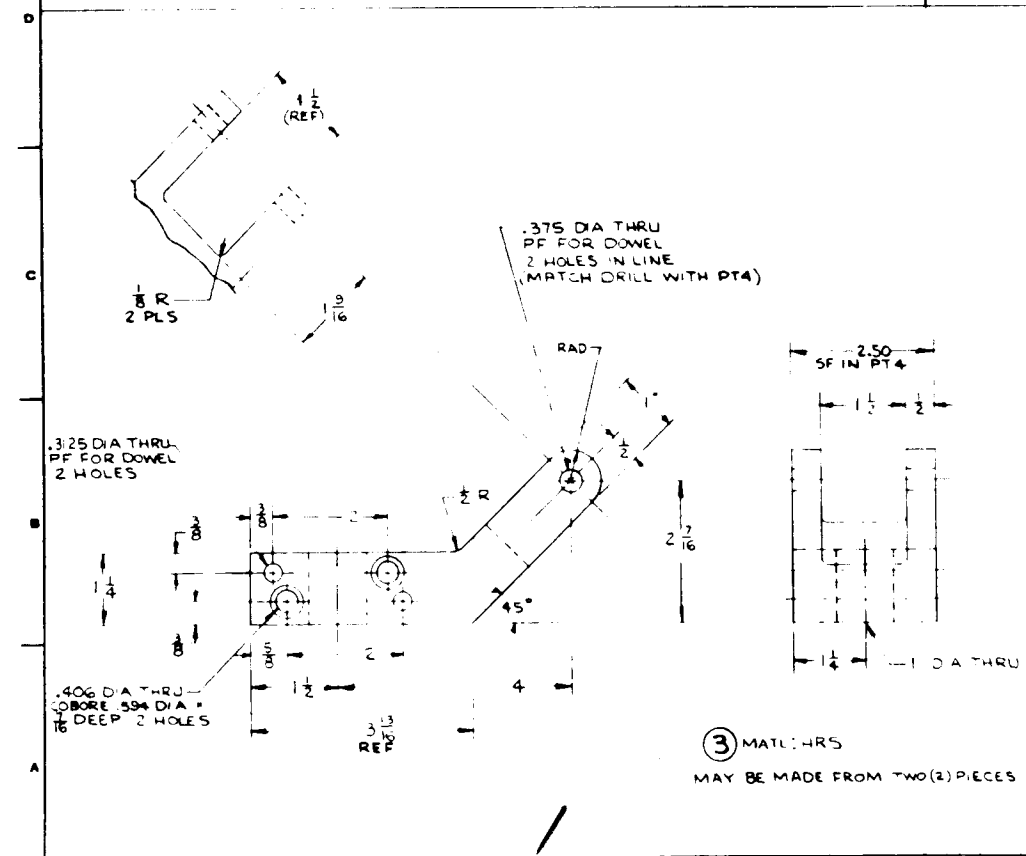
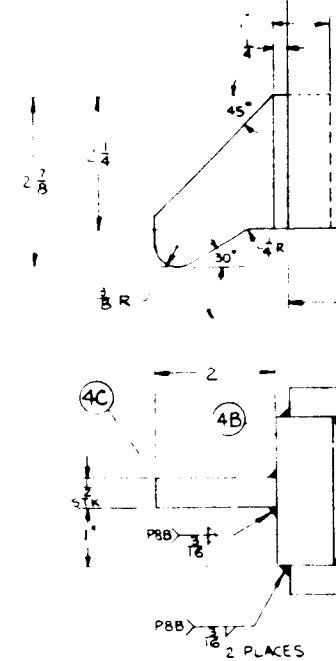
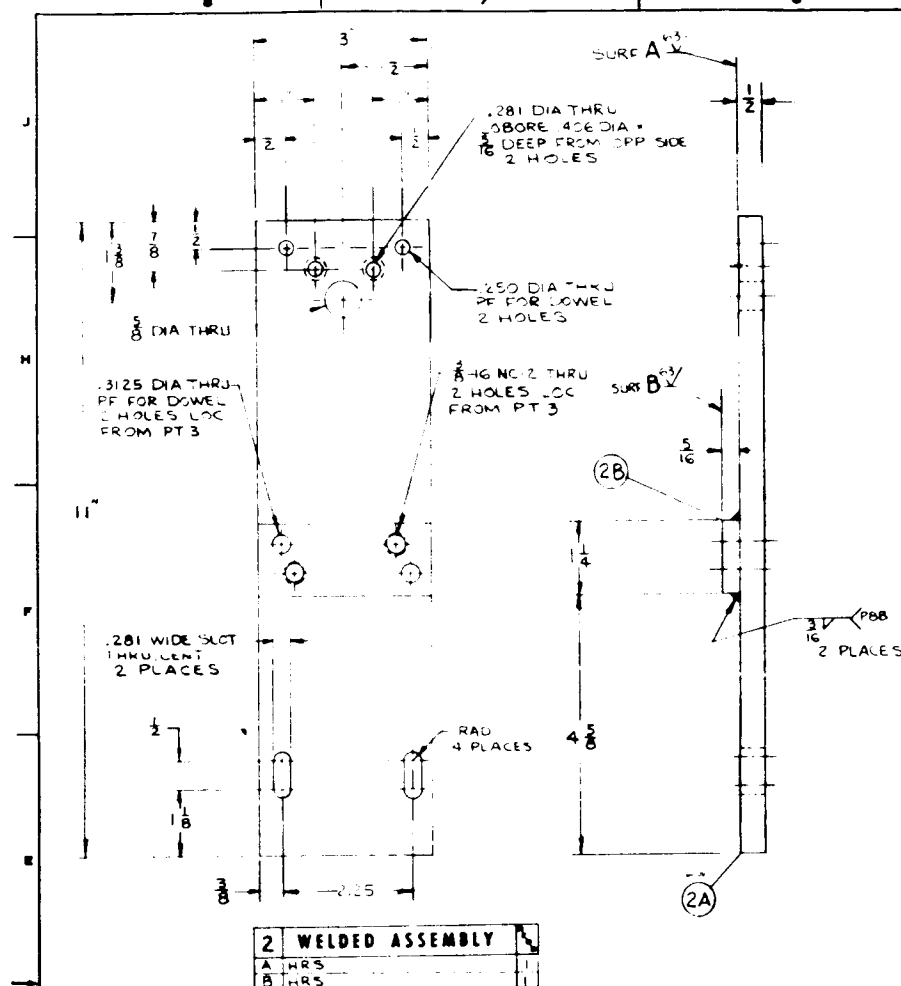
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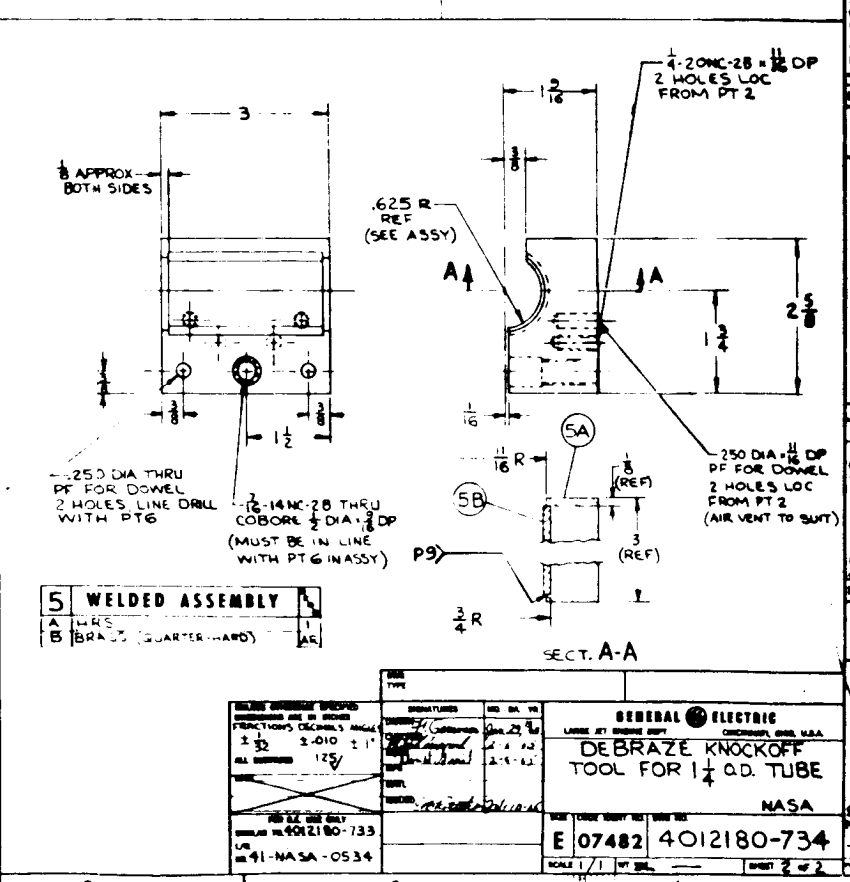
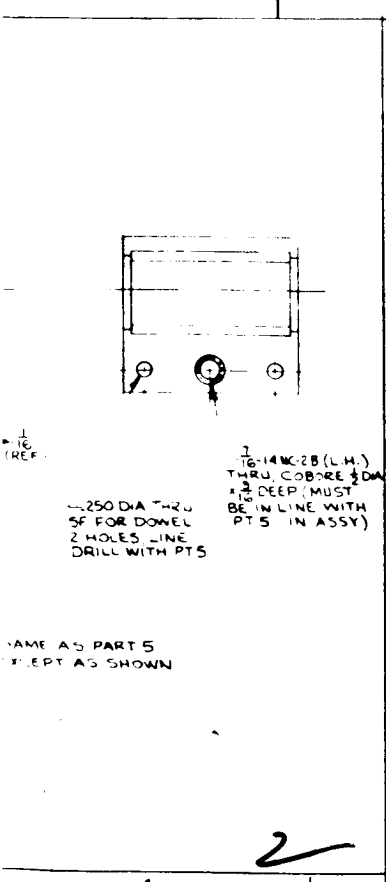
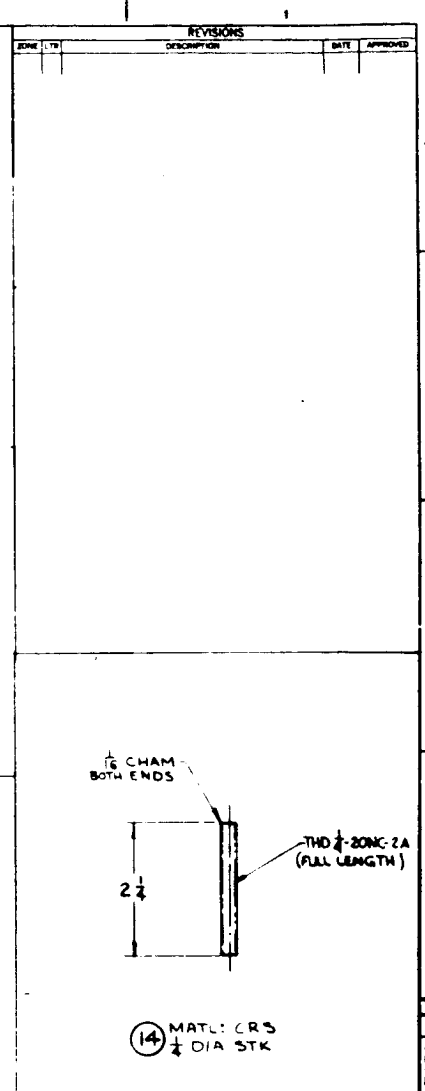
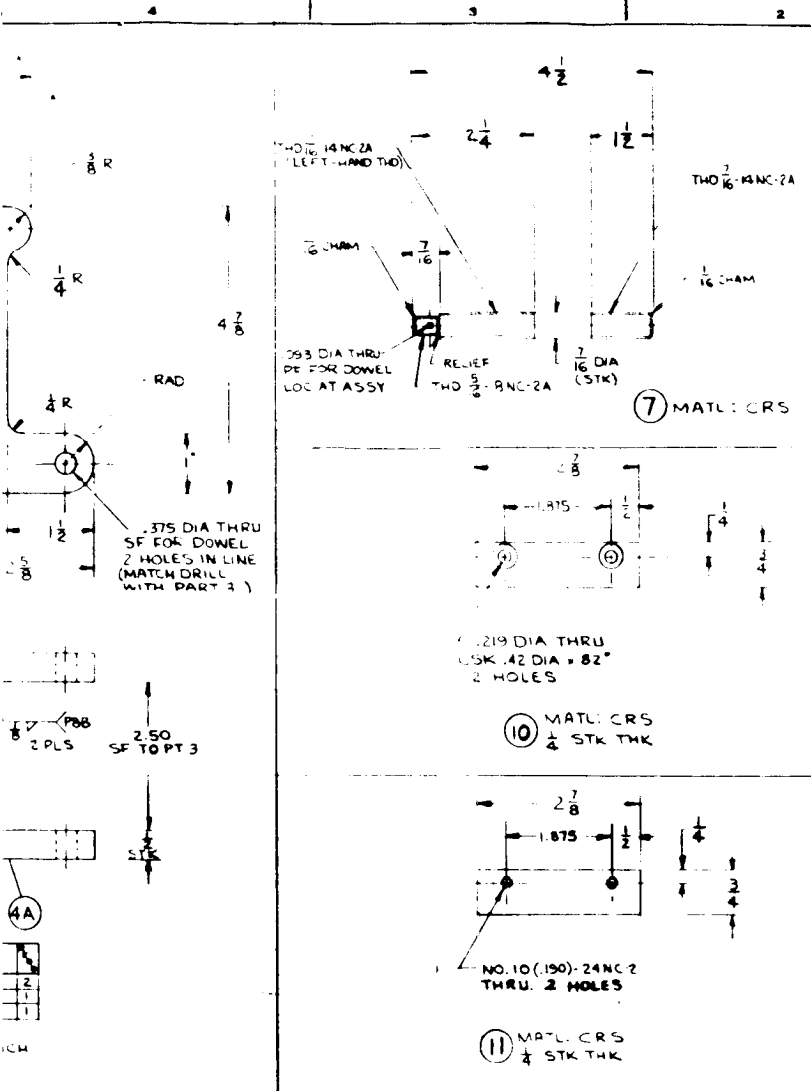
562 2 112

62
586

TABLE A-10 (continued)

- 2.46





| REVISIONS | | DATE | APPROVED |
|-----------|----------|------|----------|
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| 2 | INITIALS | | |
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| 96 | INITIALS | | |
| 97 | INITIALS | | |
| 98 | INITIALS | | |
| 99 | INITIALS | | |
| 100 | INITIALS | | |

GENERAL ELECTRIC

DEBRAZE KNOCKOFF

TOOL FOR 1/4 O.D. TUBE

NASA

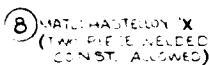
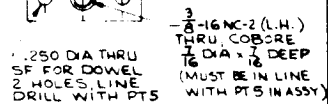
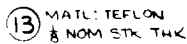
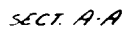
E 07482 4012180-734

SCALE 1/1

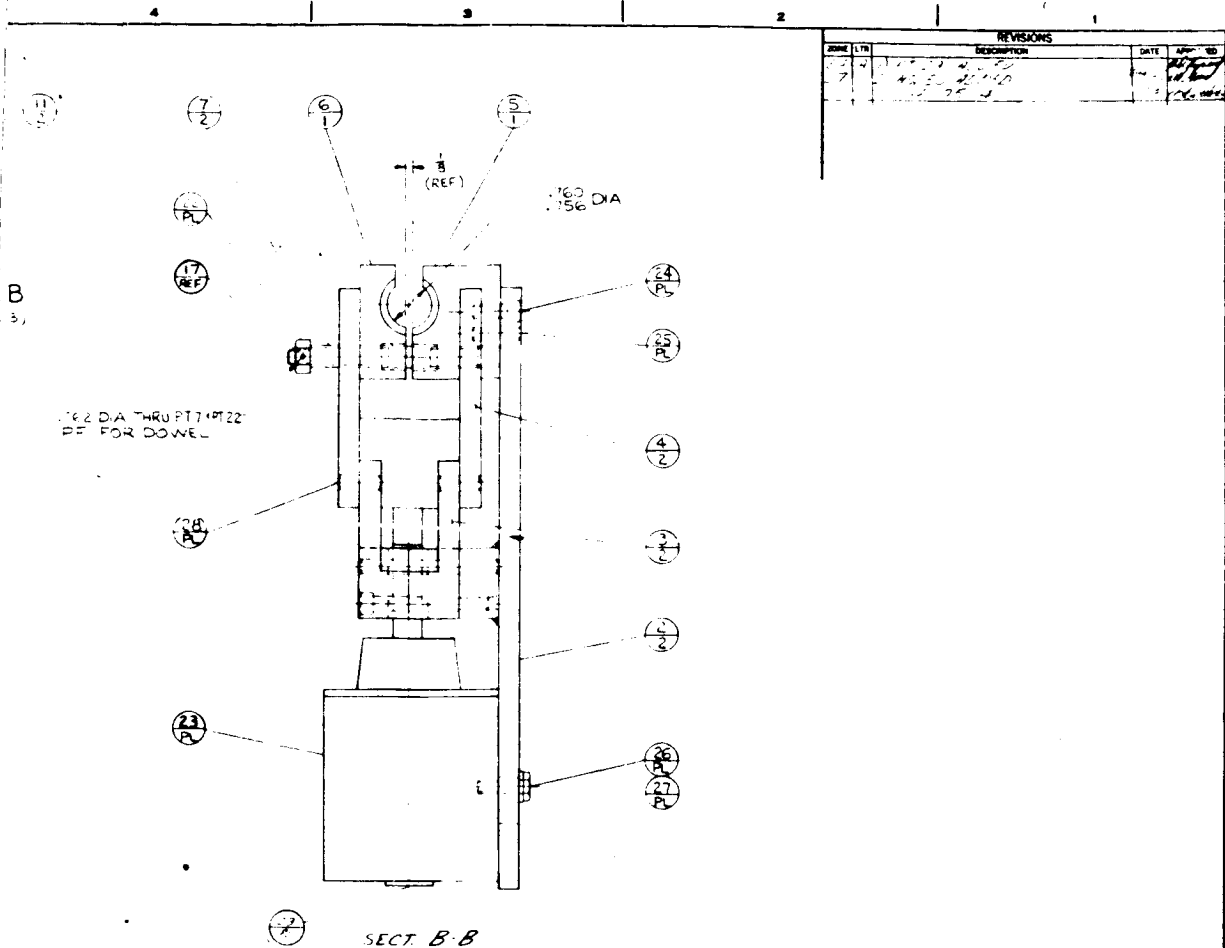
DATE 1/1

BY 1/1

1/1

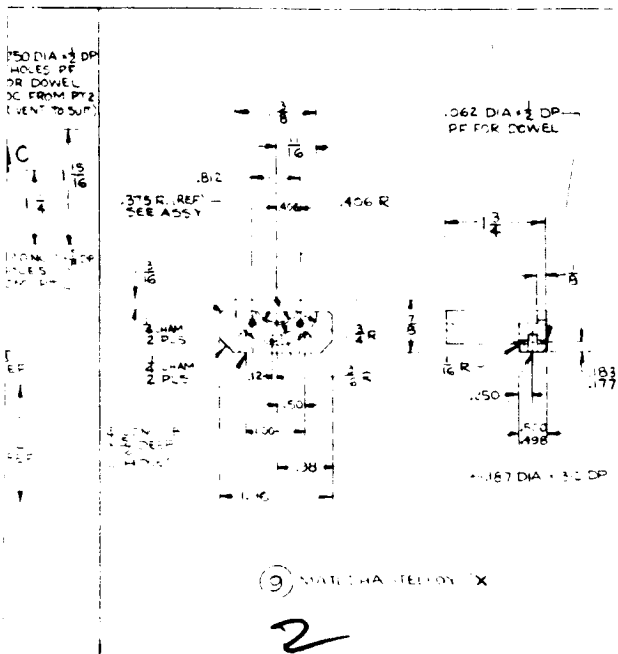


sec. C.C.



4. BLACK OXIDE, ALL NON-WORKING SURF PER AMS 2485
 3. DIAMETERS B & C TO BE MACH. AT ASSEMBLY & MUST BE CONC WITHIN .002 FIR.
 2. STAMP TOOL NO. 1/4 Q.D. TUBE, # NAS8-11554
 1. BREAK ALL SHARP EDGES

NOTES:

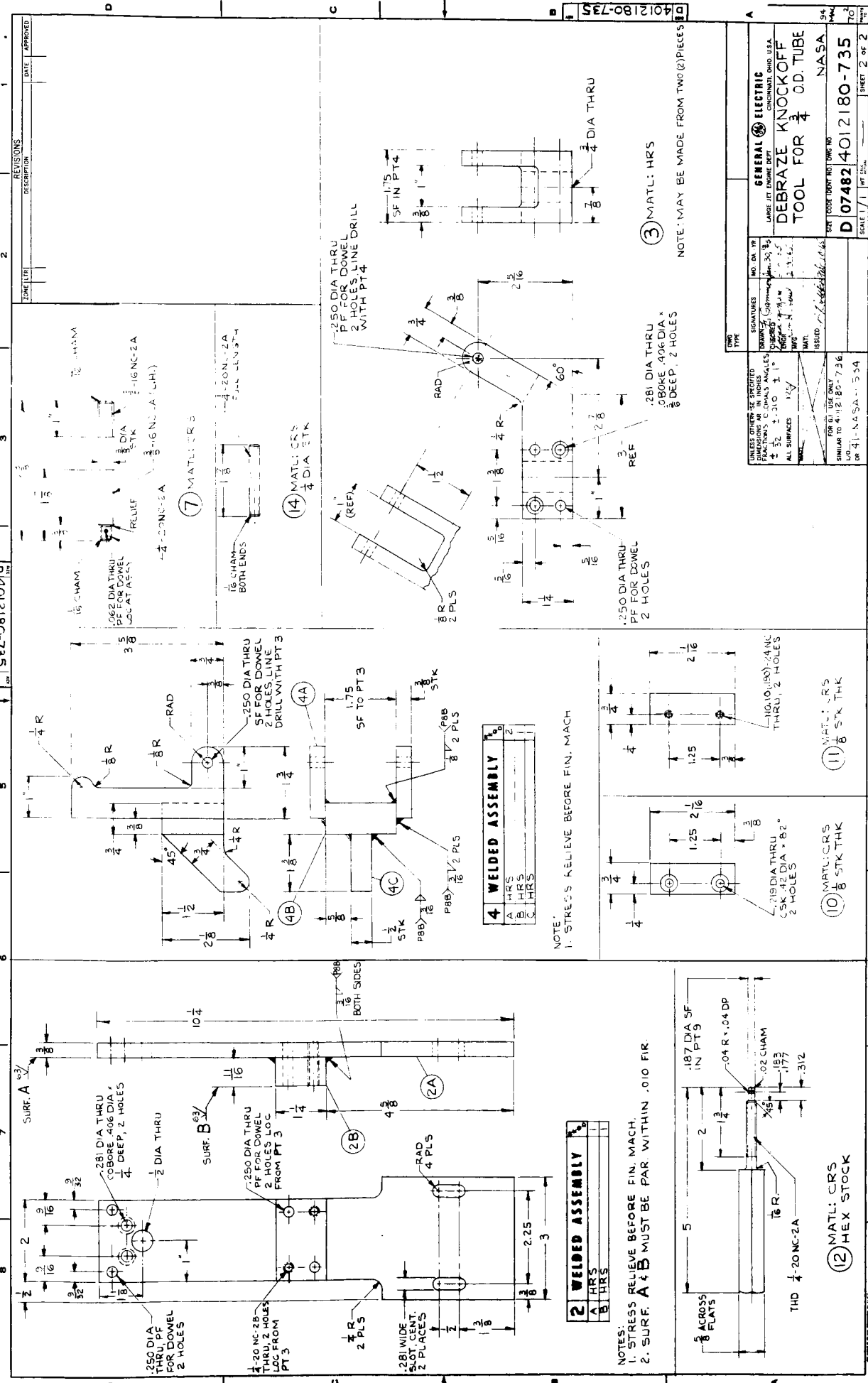


| QTY | DESCRIPTION | QTY | DESCRIPTION |
|-----|-------------|-----|------------------------------------|
| 1 | COMM | 20 | DOWEL 1/4 DIA x 3/4 LG |
| 2 | COMM | 27 | WASHER 1/4 NOM ID |
| 2 | COMM | 28 | HEX HD SCR 1/4-20NC-2 x 1/4 LG |
| 2 | COMM | 29 | DOWEL 1/4 DIA x 1/2 LG |
| 2 | COMM | 24 | SOC HD CAP SCR 1/4-20NC-2 x 3/4 LG |
| 1 | MEAD CO. | 23 | CYLINDER NG-H42 |
| 1 | COMM | 22 | HEX NUT 1/4-20NC-2 (ALTER) |
| 2 | COMM | 21 | DOWEL 1/4 DIA x 2 LG |
| 2 | COMM | 20 | SOC HD CAP SCR 1/4-20NC-2 x 2 LG |
| 2 | COMM | 19 | DOWEL 1/4 DIA x 2 1/2 LG |
| 2 | COMM | 18 | FL HD SCR NG-5 (125) 40NC x 3/8 LG |
| 2 | COMM | 17 | DOWEL 1/8 DIA x 1/2 LG |
| 2 | COMM | 16 | FL HD SCR 1/4-20NC-2 x 3/4 LG |
| 2 | COMM | 15 | HEX JAM NUT 1/4-20NC-2 |
| 2 | COMM | 14 | STUD |
| 2 | COMM | 13 | GUIDE |
| 2 | COMM | 12 | ADJUSTING SCREW |
| 2 | COMM | 11 | PLATE |
| 2 | COMM | 10 | PLATE |
| 2 | COMM | 9 | PUSHER PAD |
| 2 | COMM | 8 | PUSHER BLOCK |
| 2 | COMM | 7 | CLAMP SCREW |
| 2 | COMM | 6 | CLAMP BLOCK |
| 2 | COMM | 5 | CLAMP BLOCK |
| 2 | COMM | 4 | YOKE |
| 2 | COMM | 3 | BRACKET |
| 2 | COMM | 2 | PLATE |
| 2 | COMM | 1 | ASSEMBLY |

UNLESS OTHERWISE SPECIFIED
 DIMENSIONS ARE IN INCHES
 TOLERANCES ARE:
 FRACTIONS DECIMAL ANGLES
 24 .010 2 1/2
 ALL SURFACES
 FINISH
 FOR USE ONLY
 SIMILAR 40 2 30 1 30
 IN 41 NAS 1-0534

| | | |
|---|------------|--------------|
| SIGNATURES | | NO. OF PAGES |
| DESIGNED BY | CHECKED BY | DATE |
| GENERAL ELECTRIC | | |
| LARGE SET ENGINE DEPT. FACHENB. DIV. U.S.A. | | |
| DEBRASE KNOCKOFF | | |
| TOOL FOR 1/4 Q.D. TUBE | | |
| NASA | | |
| E 07482 4012180-735 | | |

587-08121070



2 WELDED ASSEMBLY
A HRS
B HRS

NOTES:
1. STRESS RELIEVE BEFORE FIN. MACH.
2. SURF. A & B MUST BE PAR. WITHIN .010 FIR.

4 WELDED ASSEMBLY
A HRS
B HRS
C HRS

NOTE:
1. STRESS RELIEVE BEFORE FIN. MACH.

12 MATL: CRS
HEX STOCK

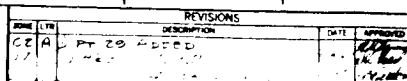
11 MATL: CRS
1/8" SK THK

10 MATL: CRS
1/8" SK THK

3 MATL: HRS

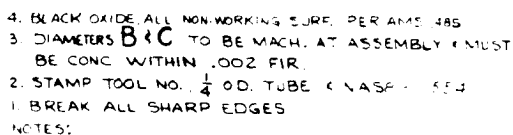
NOTE: MAY BE MADE FROM TWO (2) PIECES

| | | | |
|------------------------|--|-------------|--|
| GENERAL ELECTRIC | | NO. DA. 118 | |
| LARGE JET ENGINE | | 30-31 | |
| DEBRAZE KNOCKOFF | | 3-15 | |
| TOOL FOR 1/4" OD. TUBE | | 3-15-61 | |
| NASC | | 3-15-61 | |
| D 07482 4012180-735 | | 3-15-61 | |
| SCALE 1/1" = 1" DIA. | | 3-15-61 | |
| SHEET 2 OF 2 | | 3-15-61 | |



.062 DIA TMRJ PT 7122
PF FOR DOWEL

23) **SECT. B-B**

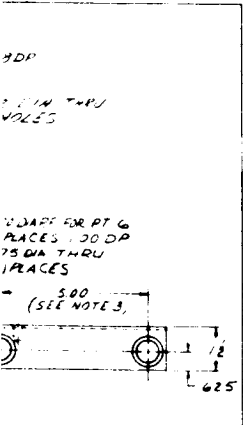
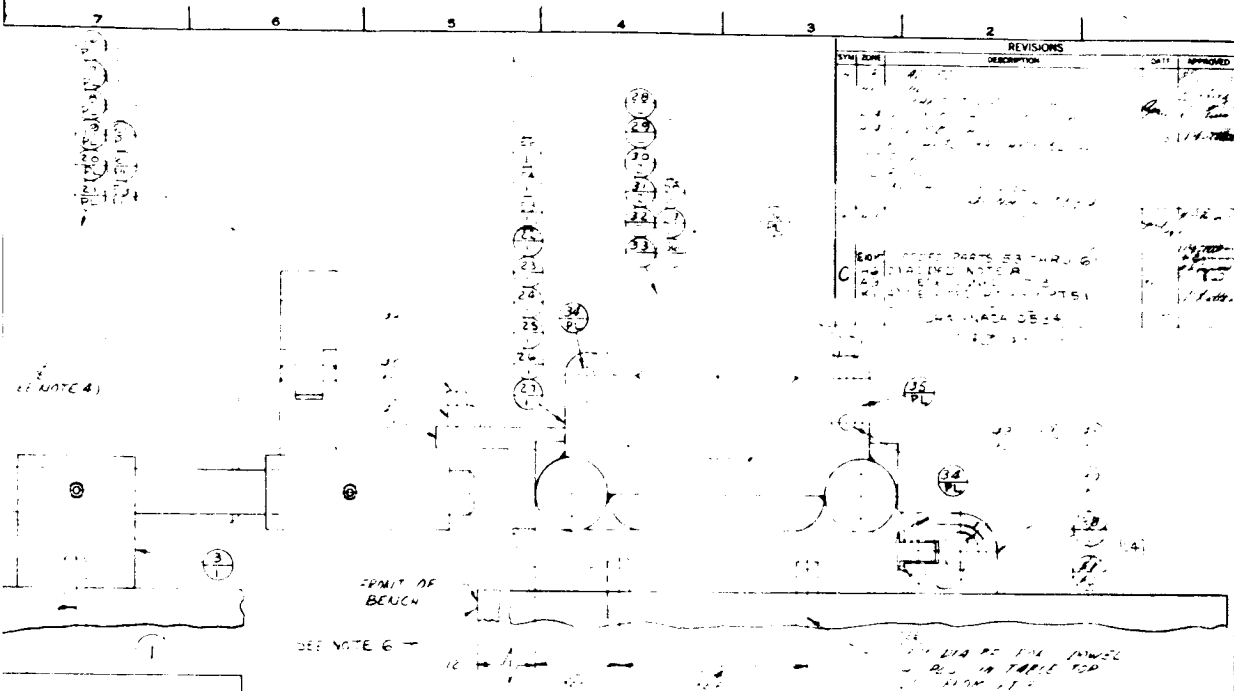


| COMPONENT | | QTY | DESCRIPTION |
|-----------|---------|-----|---|
| 1 | MEAD CO | 1 | 25 "P" CONNECTOR NO. 4-2007 |
| 2 | | 1 | 26 CYLINDER NO. 42 |
| 2 | | 1 | 27 WASHER 1/4" DIA. 10 |
| 2 | | 1 | 28 HEX HD S-REW 1/4-20NC + 1/4 LG |
| 2 | | 1 | 29 DOWEL 1/4 DIA + 7/8 LG |
| 2 | | 1 | 24 SK HD WASHER 1/4-20NC + 3/4 LG |
| 2 | | 1 | 23 DOWEL 1/4 DIA + 3/4 LG |
| 1 | | 1 | 22 HEX NUT 1/4-20NC (ALTER) |
| 2 | | 1 | 21 DOWEL 1/4 DIA + 2" LG |
| 2 | | 1 | 20 BUSH HD CAP 1/4-20NC |
| 2 | | 1 | 19 DOWEL 1/4 DIA + 2 1/2 LG |
| 2 | | 1 | 18 FL HD SCR NO. 5 (15) 4NC + 3/8 LG |
| 2 | | 1 | 17 DOWEL 1/8 DIA + 1/2 LG |
| 2 | | 1 | 16 FL HD S-REW NO. 10 (10) 4NC + 3/4 LG |
| 2 | | 1 | 15 HEX 4AM NUT 1/4-20NC 2 |
| 2 | | 1 | 14 STUD |
| 2 | | 1 | 13 GUIDE |
| 2 | | 1 | 12 ADJUSTING SCREEN |
| 2 | | 1 | 11 PLATE |
| 2 | | 1 | 10 PLATE |
| 2 | | 1 | 9 P-SHER PAD |
| 2 | | 1 | 8 PUSHER BLOCK |
| 2 | | 1 | 7 CLAMP BLOCK |
| 2 | | 1 | 6 CLAMP BLOCK |
| 2 | | 1 | 5 CLAMP BLOCK |
| 2 | | 1 | 4 COKE |
| 2 | | 1 | 3 BRACKET |
| 2 | | 1 | 2 PLATE |
| 2 | | 1 | 1 ASSEMBLY |

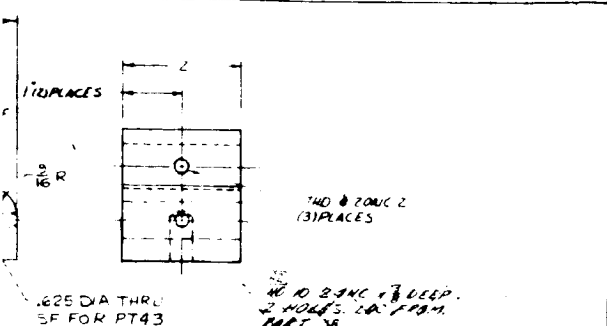
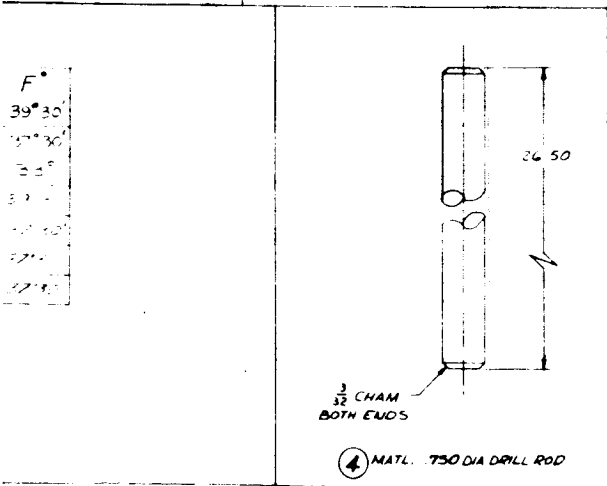
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TYPED IN FRACTIONS ON
FRACTIONS DECIMALS ANGLES
±.000 ±.010 ±.1°
ALL SURFACES (23/

FOR G.E. LIST ONLY
SIMILAR TO 4012180-735
1/0
OR 41-NASA-0534

GENERAL ELECTRIC
LARGE MET. ENGR'G DEPT. CINCINNATI, OHIO, U.S.A.
DEBRAZE KNOCKOFF
TOOL FOR 1/4" QD TUBE
NASA
SIZE CODE PART NO. DRAWING NO.
E 07482 4012180-736



9. IDENTIFY ALL LOOSE PARTS WITH TOOL NO. (TOOL NO. 10) ENDING IN 13 IN THRU 33 AND 14 IN THRU 34
7. BREAK ALL SHARP EDGES
6. IDENTIFY ALL TOOL NUMBER LATEST TOOL REV. LETTER AND 14
5. MARK SIDE ALL STEEL PARTS PER AMS 2495
1. HOLLOWELL WORK BENCH MODEL NO. 603 (6'0" W x 1'35" H) WITH PRESWOOD COVERED RED STEEL TOP NO. 6000-M (1) 1 DAWNER TIER UNITS NO. 120 SIZE 14 x 20 1/4 MOUNTING KITS NO. 14



| | |
|---------------------------|-----------------------------|
| 1. COMM. COGS DILL TOOLS | 1. CLAMP - LOWER (375 DIA) |
| 2. COMM. COGS DILL TOOLS | 2. CLAMP - UPPER (375 DIA) |
| 3. COMM. COGS DILL TOOLS | 3. CLAMP - LOWER (375 DIA) |
| 4. COMM. COGS DILL TOOLS | 4. CLAMP - UPPER (375 DIA) |
| 5. COMM. COGS DILL TOOLS | 5. CLAMP - LOWER (375 DIA) |
| 6. COMM. COGS DILL TOOLS | 6. CLAMP - UPPER (375 DIA) |
| 7. COMM. COGS DILL TOOLS | 7. CLAMP - LOWER (375 DIA) |
| 8. COMM. COGS DILL TOOLS | 8. CLAMP - UPPER (375 DIA) |
| 9. COMM. COGS DILL TOOLS | 9. CLAMP - LOWER (375 DIA) |
| 10. COMM. COGS DILL TOOLS | 10. CLAMP - UPPER (375 DIA) |
| 11. COMM. COGS DILL TOOLS | 11. CLAMP - LOWER (375 DIA) |
| 12. COMM. COGS DILL TOOLS | 12. CLAMP - UPPER (375 DIA) |
| 13. COMM. COGS DILL TOOLS | 13. CLAMP - LOWER (375 DIA) |
| 14. COMM. COGS DILL TOOLS | 14. CLAMP - UPPER (375 DIA) |
| 15. COMM. COGS DILL TOOLS | 15. CLAMP - LOWER (375 DIA) |
| 16. COMM. COGS DILL TOOLS | 16. CLAMP - UPPER (375 DIA) |
| 17. COMM. COGS DILL TOOLS | 17. CLAMP - LOWER (375 DIA) |
| 18. COMM. COGS DILL TOOLS | 18. CLAMP - UPPER (375 DIA) |
| 19. COMM. COGS DILL TOOLS | 19. CLAMP - LOWER (375 DIA) |
| 20. COMM. COGS DILL TOOLS | 20. CLAMP - UPPER (375 DIA) |
| 21. COMM. COGS DILL TOOLS | 21. CLAMP - LOWER (375 DIA) |
| 22. COMM. COGS DILL TOOLS | 22. CLAMP - UPPER (375 DIA) |
| 23. COMM. COGS DILL TOOLS | 23. CLAMP - LOWER (375 DIA) |
| 24. COMM. COGS DILL TOOLS | 24. CLAMP - UPPER (375 DIA) |
| 25. COMM. COGS DILL TOOLS | 25. CLAMP - LOWER (375 DIA) |
| 26. COMM. COGS DILL TOOLS | 26. CLAMP - UPPER (375 DIA) |
| 27. COMM. COGS DILL TOOLS | 27. CLAMP - LOWER (375 DIA) |
| 28. COMM. COGS DILL TOOLS | 28. CLAMP - UPPER (375 DIA) |
| 29. COMM. COGS DILL TOOLS | 29. CLAMP - LOWER (375 DIA) |
| 30. COMM. COGS DILL TOOLS | 30. CLAMP - UPPER (375 DIA) |
| 31. COMM. COGS DILL TOOLS | 31. CLAMP - LOWER (375 DIA) |
| 32. COMM. COGS DILL TOOLS | 32. CLAMP - UPPER (375 DIA) |
| 33. COMM. COGS DILL TOOLS | 33. CLAMP - LOWER (375 DIA) |
| 34. COMM. COGS DILL TOOLS | 34. CLAMP - UPPER (375 DIA) |

| | |
|--|-------------|
| GENERAL ELECTRIC LARGEST SET BENCH SHIP CONSTRUCTION 14, 000 | |
| SIZING TOOL - TUBE END | |
| 07482 E 4012180-729 | 4012180-729 |

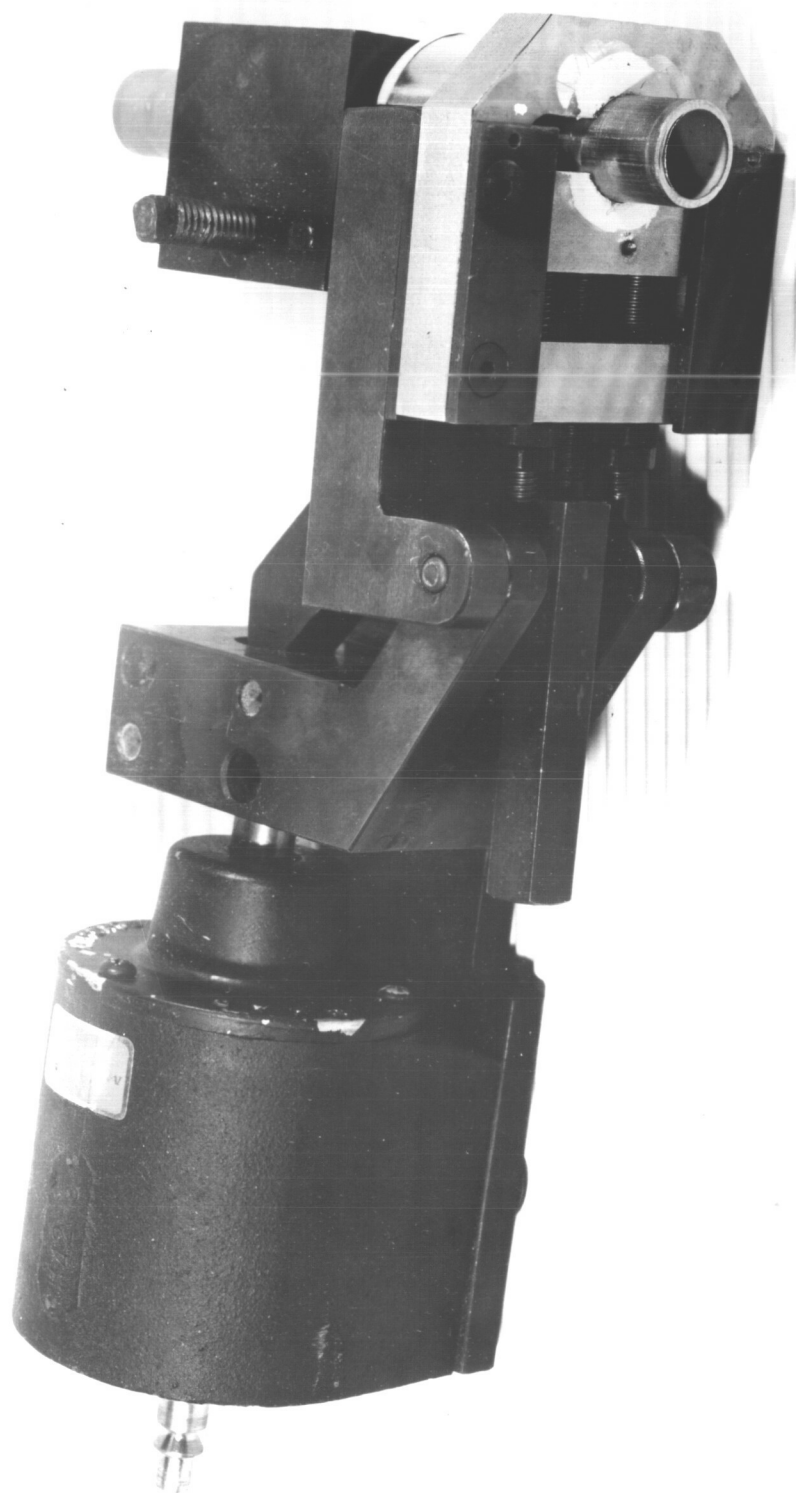


FIGURE 13

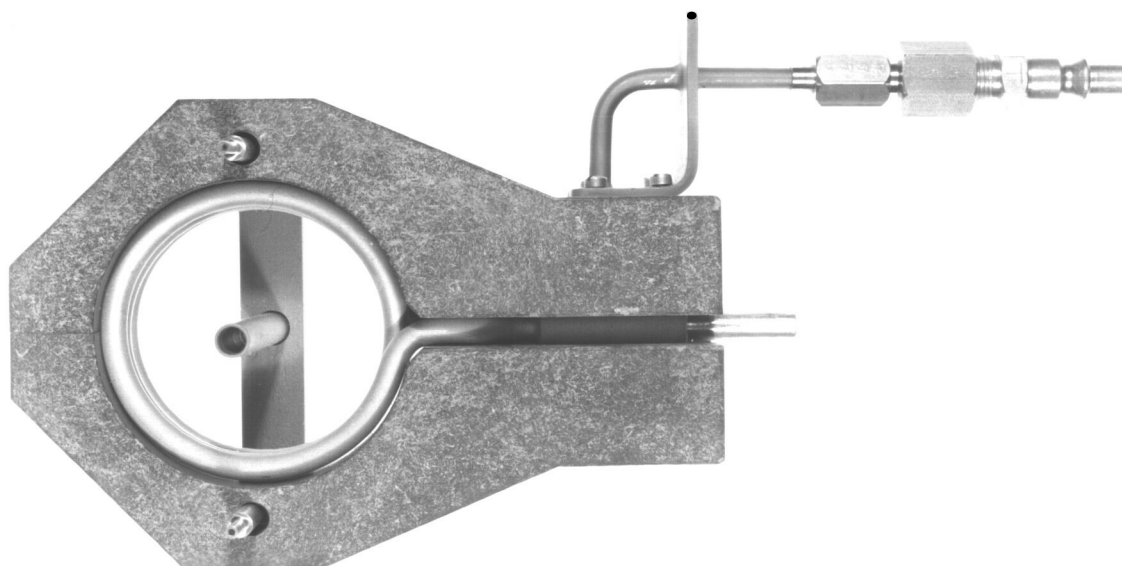
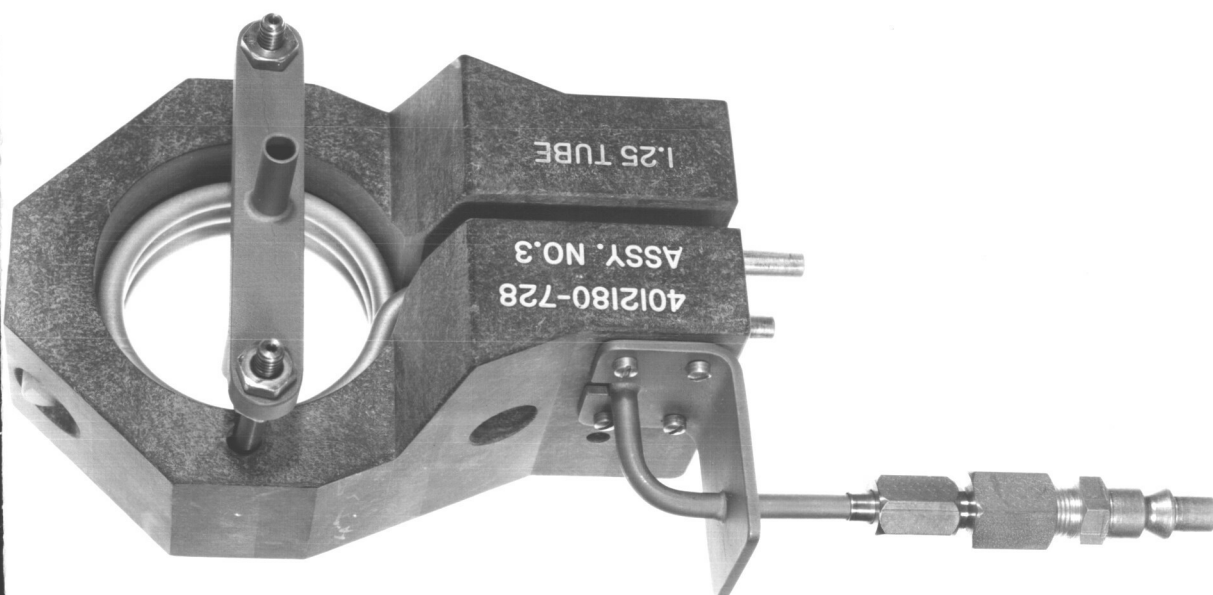
DEBRAZING FIXTURE

MO4761

HEATING COILS FOR DEBRAZING FIXTURES

FIGURE 14

MO1761



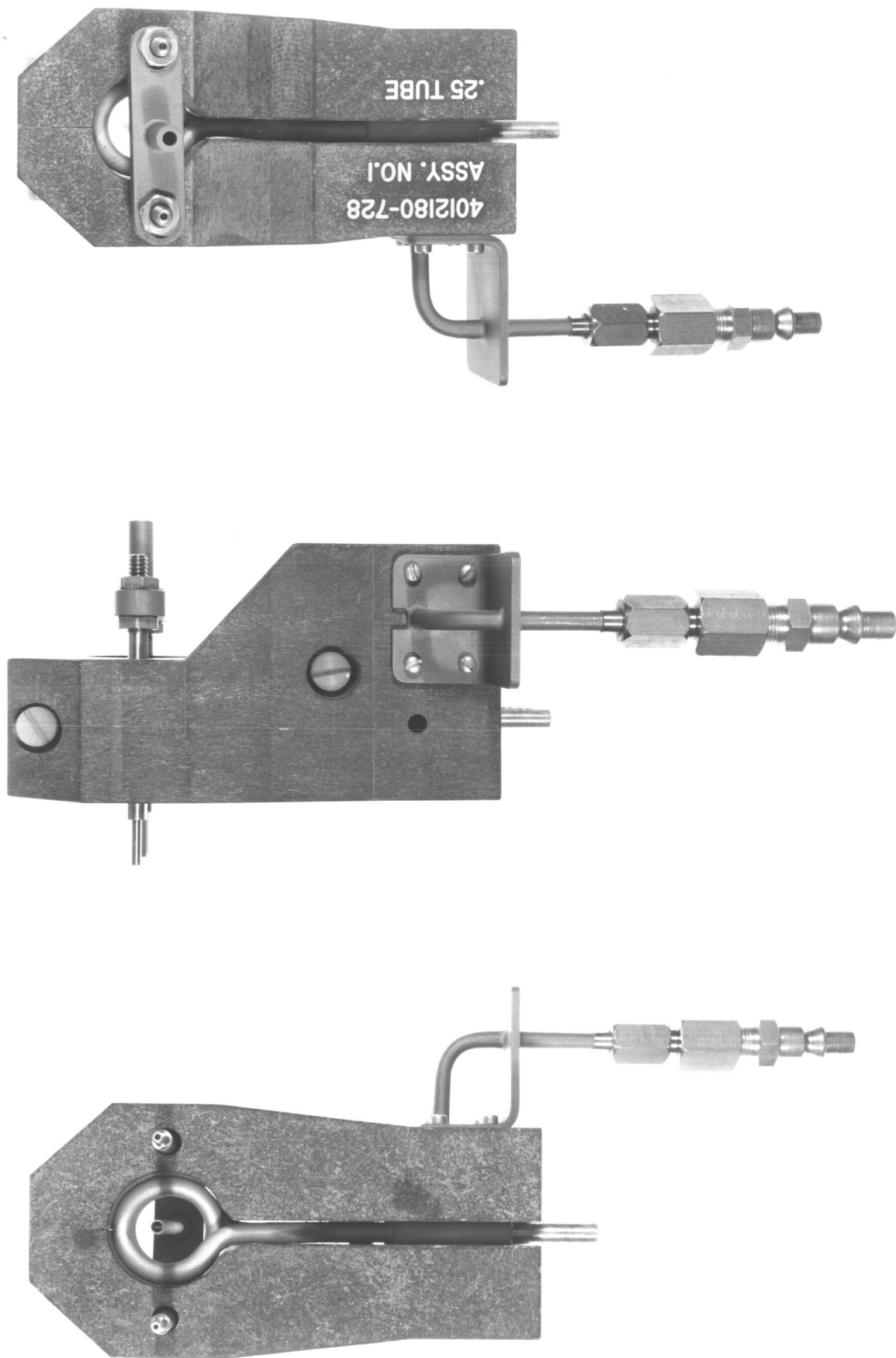


FIGURE 11A HEATING COILS FOR DEBRAZING FIXTURES

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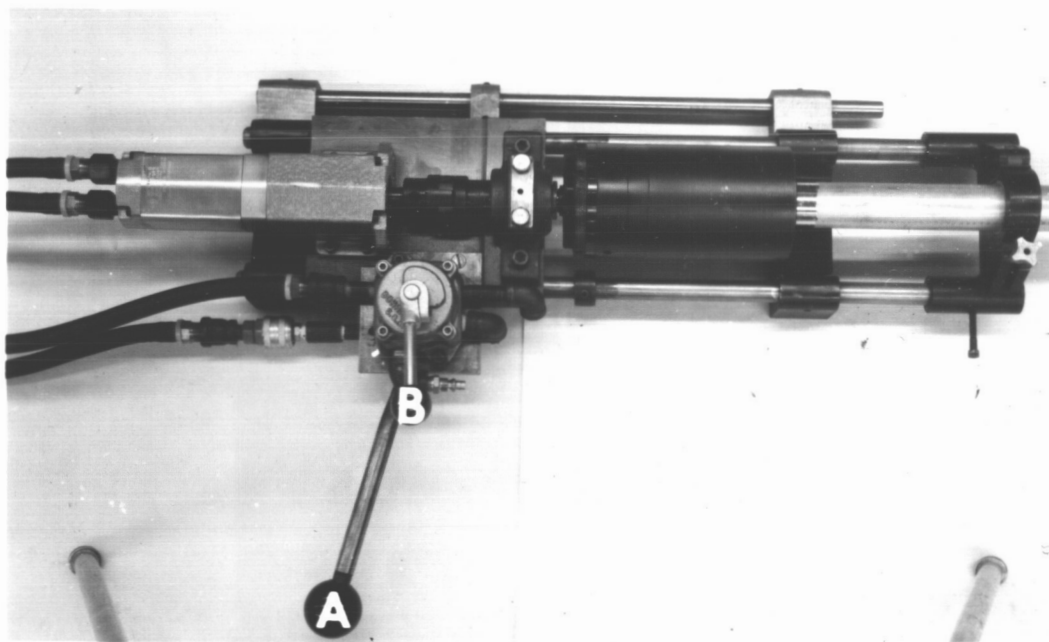


FIGURE 15

TOP & SIDE VIEW OF SIZING TOOL
(A-Lever Arm B-Air Reversing Switch)

MO4761



FIGURE 16

1/4" SIZING HOUSING & CLAMPING BLOCK

MO4761

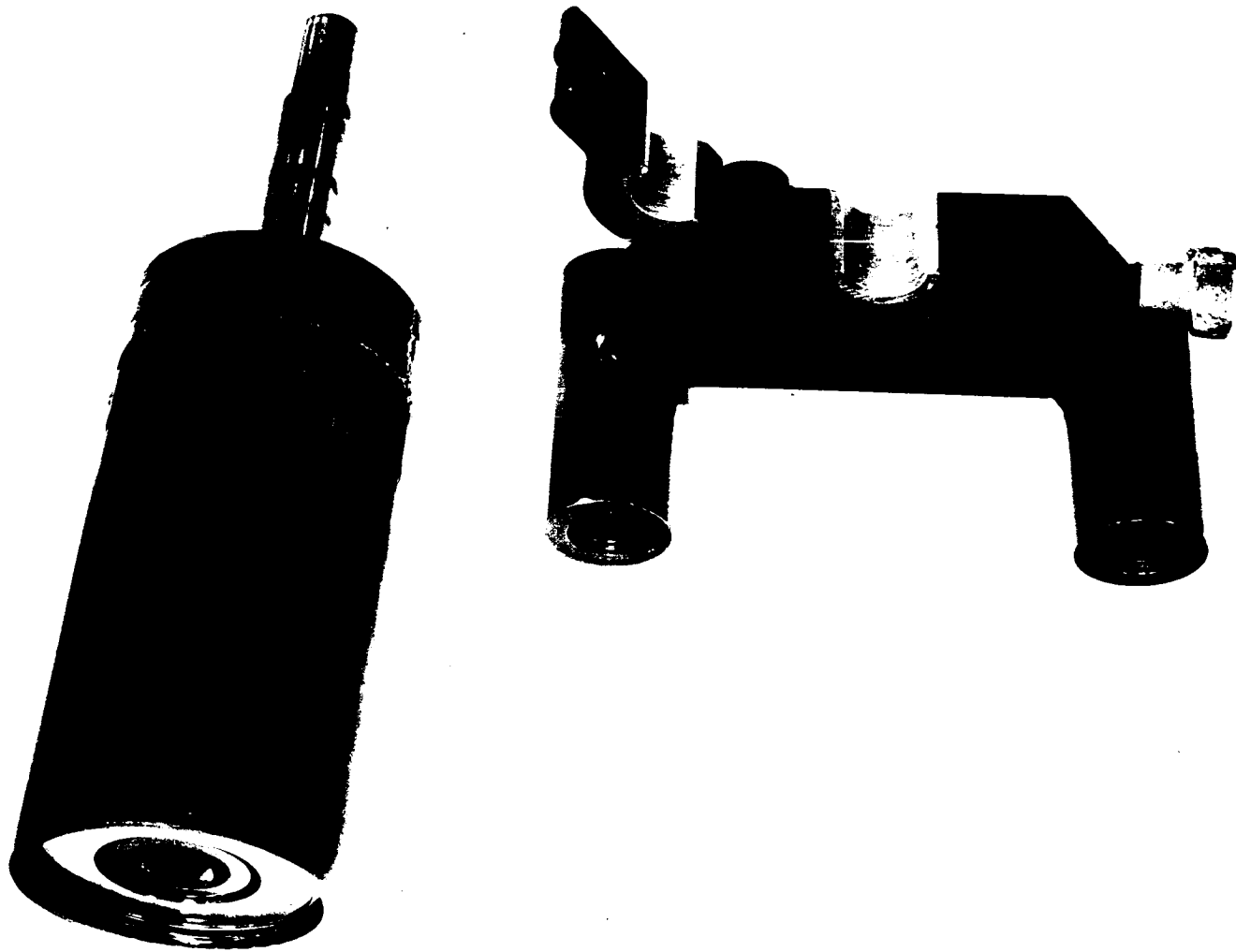


FIGURE 16A

3/4" SIZING HOUSING & CLAMPING BLOCK

MO4761

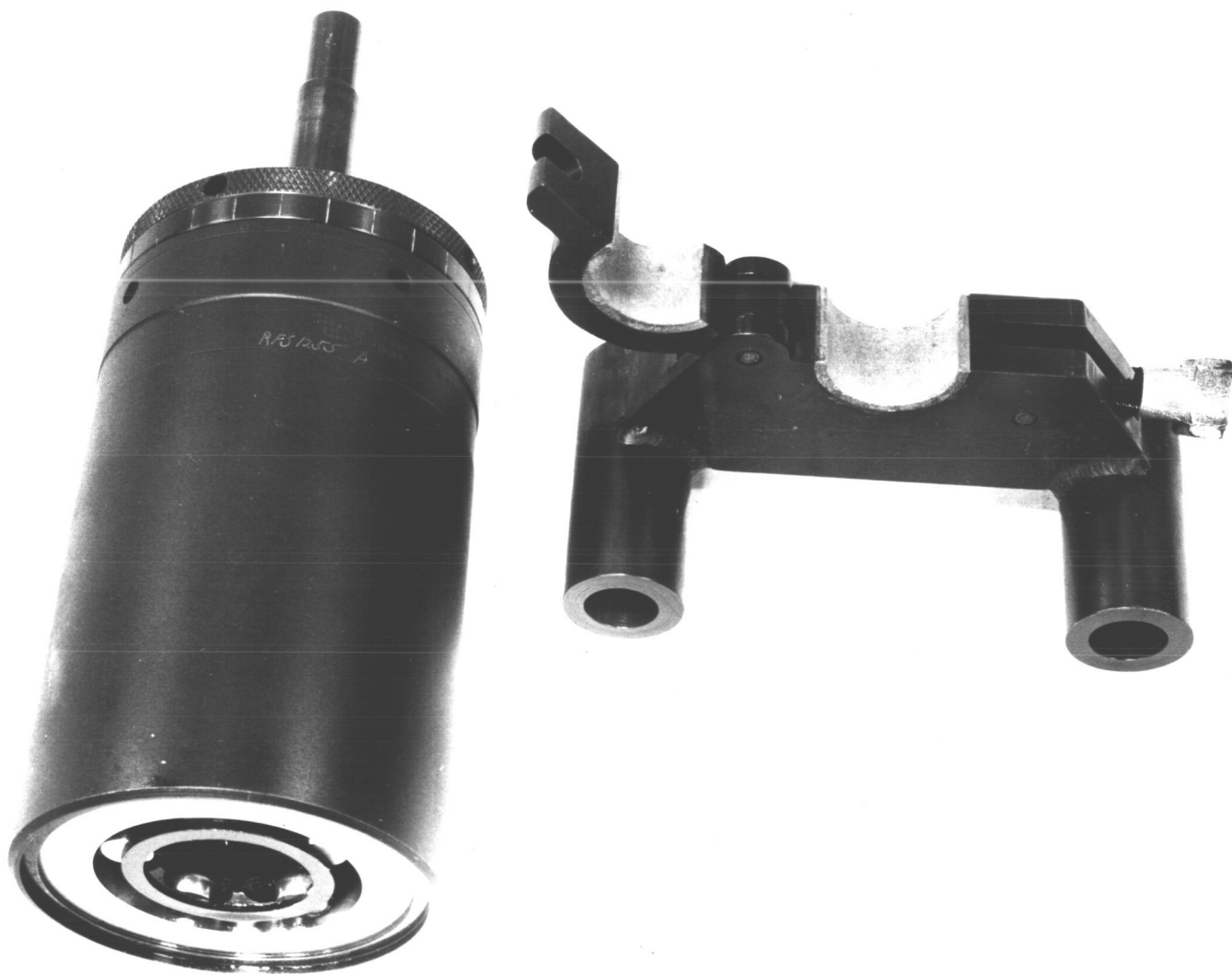


FIGURE 16B

1 1/4" SIZING HOUSING & CLAMPING BLOCK

m04761

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Sizing Tools (Cont'd)

The sizing of all tubing is accomplished by roll forgings (or forming). When the sizing tools are rotated at relatively high speeds, precision ground and hardened rolls bear on a cammed arbor; the rolls spin, rise and fall rapidly compressing the tube surface. These tools are adjustable in .0001 increments with a range from a nominal tube size dimension to $\pm .005$ inches.

The sizing operation procedure is as follows: Place a tube in the proper holder and tighten the clamp. Activate the motor. Turn to the forward position, which operates the sizing tool in a clockwise motion. The sizing tool is brought forward by means of the handle attached, while it is revolving. After initial engagement the tube will feed itself into the sizing tool. Upon completion of sizing, reverse the sizing tool rotation direction by reversing the air valve. The motor will turn the sizing tool counter clockwise immediately freeing the tubing from the hardened rolls. To disengage, pull the sizing tool back to its original position.

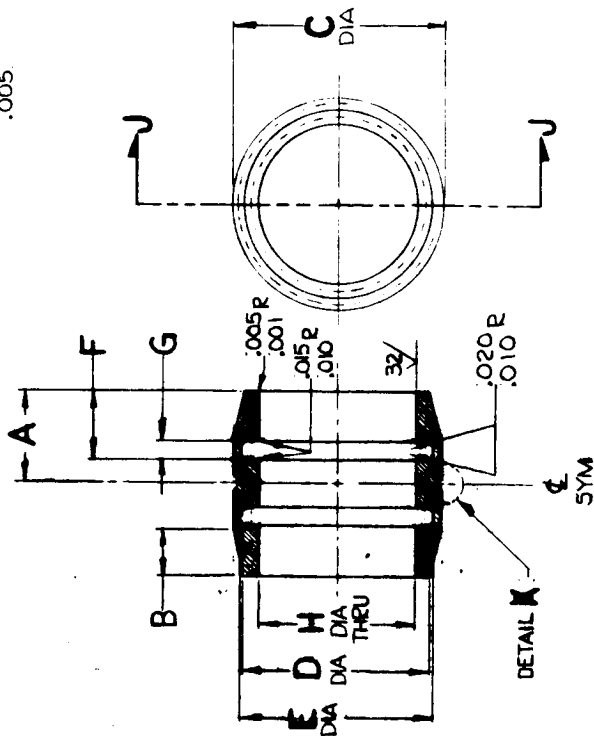
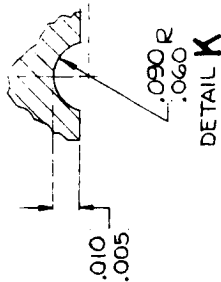
Coupling Elbow And Tee Designs

The design of the coupling, elbow, and tee fittings has evolved primarily from the fitting design used on the J93 Engine which powers the XB-70 aircraft. Sketch I and II are initial designs of a coupling first developed for the J93 fluid system. Drawing 871C234, illustrates the present coupling design for the J93 fluid system. Drawing 4012180-638 is the design of couplings used for NASA applications. The latter drawing is exactly the same as drawing 871C234 except for larger size fittings.

+.0010

The I.D. of the coupling has a critical dimension of $-.0000$ to control dimensional gaps with sized tubing. This controlled I.D. dimension is maintained on all fitting designs. Sketch I has spacers at each end of the coupling with a crown dimension of 020×030 . these spacers are used for alignment. Sketch II shows the same basic design, only the spacers have been replaced with projections thru 120° apart. These projections were also used for alignment. Drawings 871C234 and 4012180-638 show the absence of spacers or projections. Later, it was found that with controlled I.D. dimensions on the coupling and controlled tubing, the brazing alloy acted as the alignment means during braze alloy flow. The recessed groove in each half of the coupling allows for

| PART IDENT NO. | TUBE OD | A | B | C | D | E | F | G | H |
|----------------|---------|--------------|--------------|----------------|----------------|----------------|--------------|--------------|----------------|
| 4012180-638-P1 | 1.250 | .557 .547 | .330 .310 | 1.405 1.400 | 1.107 1.087 | 1.322 1.317 | .445 .425 | .085 .080 | 1.251 1.250 |
| P2 | 1.500 | .619 .609 | .383 .363 | 1.655 1.650 | 1.557 1.537 | 1.512 1.567 | .505 .485 | .092 .087 | 1.501 1.500 |
| P3 | 2.000 | .694 .684 | .449 .429 | 2.155 2.150 | 2.057 2.037 | 2.072 2.067 | .580 .560 | .101 .096 | 2.001 2.000 |
| P4 | 2.500 | .787 .777 | .528 .508 | 2.655 2.650 | 2.557 2.537 | 2.572 2.567 | .670 .650 | .112 .107 | 2.501 2.500 |
| P5 | .250 | .332 .322 | .103 .083 | .357 .352 | .307 .287 | .302 .297 | .158 .138 | .063 .058 | .251 .250 |
| P6 | .750 | .400 .390 | .213 .193 | .877 .872 | .807 .787 | .822 .817 | .292 .272 | .092 .087 | .751 .750 |



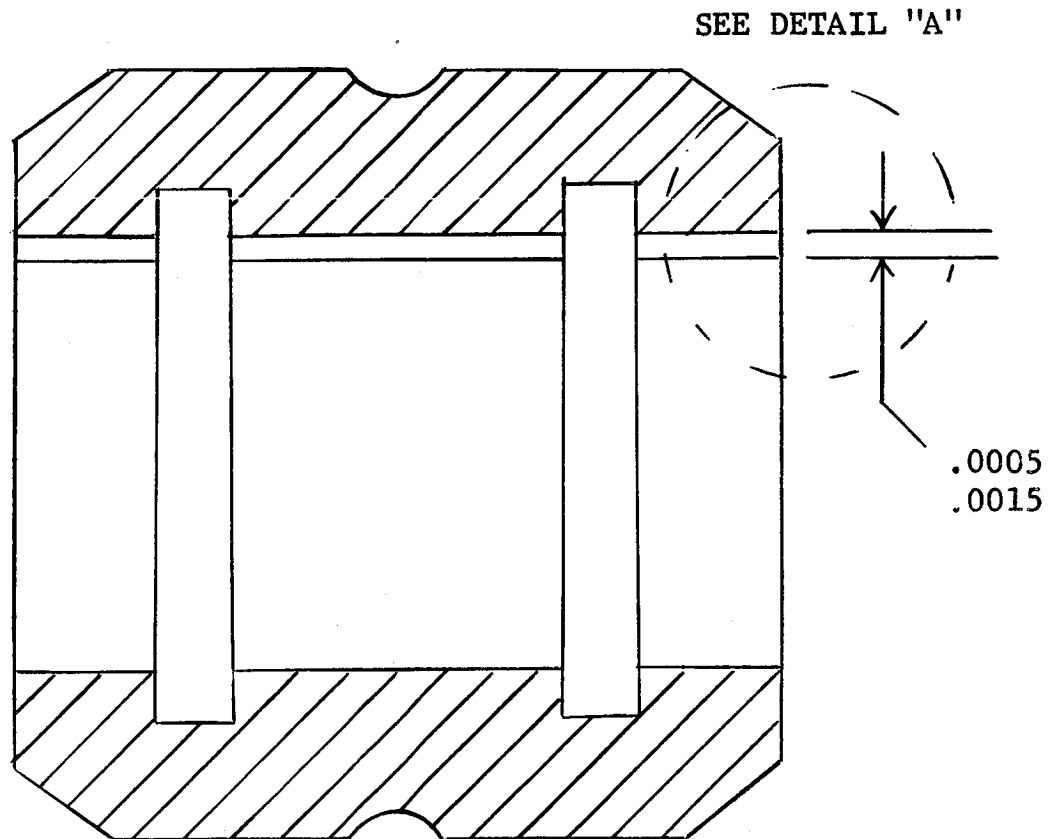
1 2 3 4 MATL: AMS 5646

5. DIA E & H MUST BE CONCENTRIC WITHIN .002 FIR.
4. DIA H MUST BE ROUND W THIN .0004 FIR.
3. COUPLINGS SHALL BE CLEANED IN A MANNER PRIOR TO PACKAGING TO REMOVE ALL DIRT, OIL, GREASE, OR FOREIGN MATERIAL DETRIMENTAL TO THE ULTIMATE BRAZING OPERATION & INDIVIDUALLY PACKAGED IN HEAT SEALED PLASTIC BAG
2. MARK CONTAINER OR TAG WITH PART IDENT. NO. & VENDOR CODE IDENT
1. SEE [GE 51-212,010] FOR INTERPRETATION OF DWG

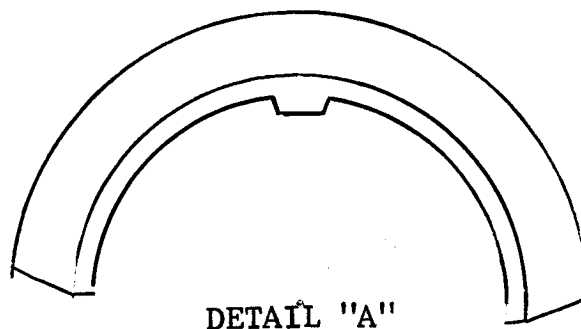
| | | | | | | | |
|--|--|---|--|--|--|-----------|--|
| SYN | | REVISIONS | | DATE | | APPROVED | |
| 4012180-638 | | | | | | | |
| GENERAL ELECTRIC LARGE JET ENGINE DEPT CINCINNATI 15, OHIO | | | | TITLE COUPLING - TUBE, BRAZED ENDS | | | |
| CODE IDENT NO. SIZE DWG NO. 07482 C 4012180-638 | | | | SCALE NONE WT 2 SHEET 2 OF 1 | | | |
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES FRACTIONS DECIMALS ANGLES + ALL SURFACES MATL | | SIGNATURES DRAWN CHECKED ENGR WPG MATL ISSUED | | DATE JULY 13, 1963 | | PRINTS TO | |
| FOR G.E. USE ONLY SIMILAR TO L/O DR 41-07-250.01 | | | | | | | |

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SKETCH 1

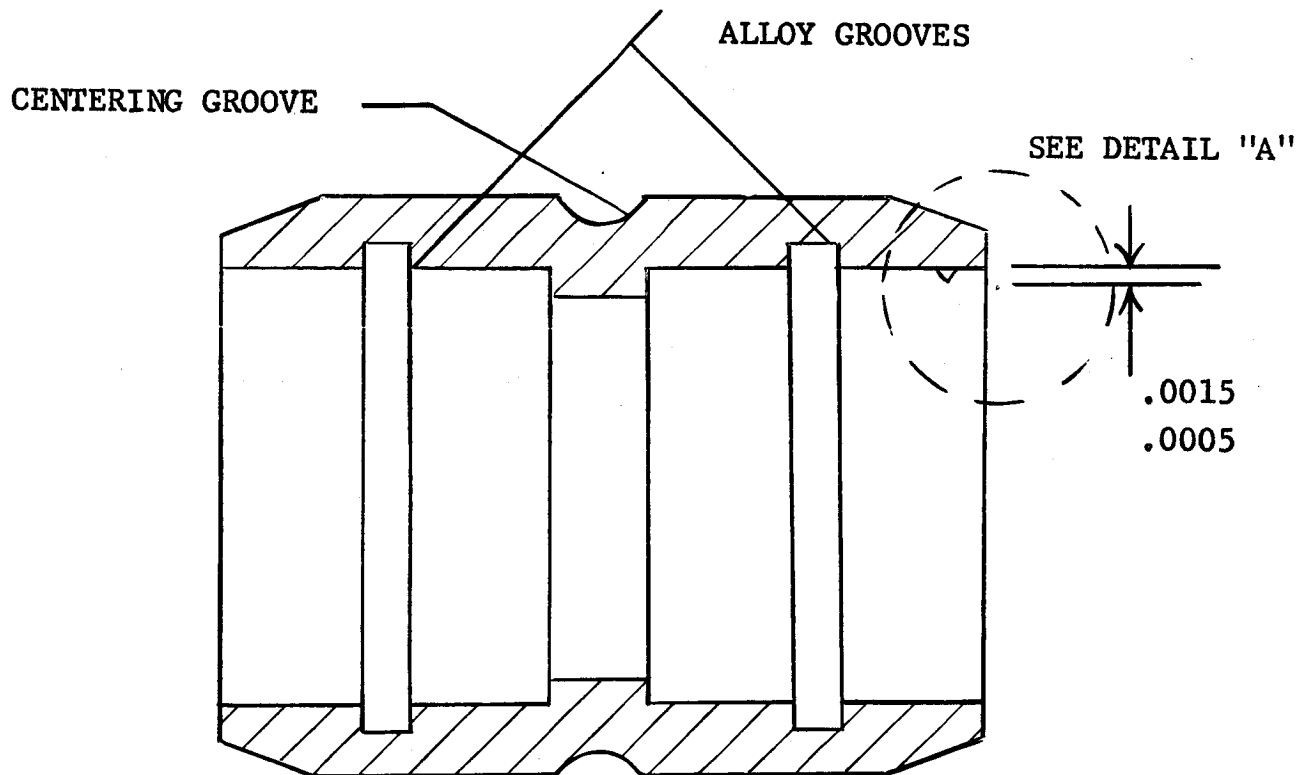


3 PROJECTIONS THRU
120° APART .040 - .080 WIDE

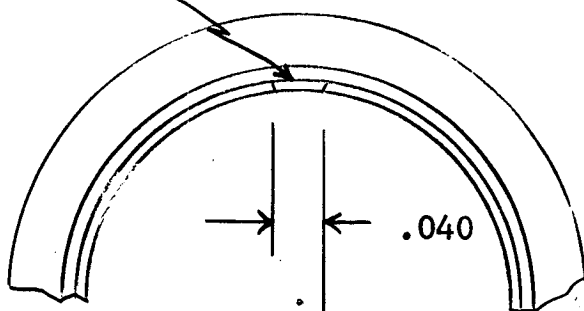


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TECHNICAL INFORMATION SERIES
NO. R66FPD47

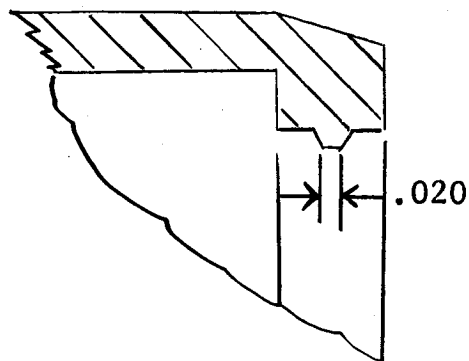
SKETCH 2



3 PROJECTIONS
SPACED 120°



DETAIL "A"



TECHNICAL INFORMATION SERIES

NO. R66FPD47

Coupling Elbow And Tee Designs (Cont'd)

rectangular snap rings of braze alloy (print 4012180-639). Preplacing the alloy insures soundly brazed coupling, when the alloy has flowed out and formed a continuous fillet around the periphery of the coupling. If the alloy is preplaced externally there is no assurance that the alloy has flowed into the coupling joint. The shallow centering trough on the outside of the coupling is for parting purposes when it becomes desirable to disassemble. This coupling design is reliable and economical to manufacture compared to the other designs. Print 4012180-638 details production couplings.

Elbow and tee fittings were also evolved from the basic design of the J93 fluid system coupling. Both the elbow and the tee fittings have a internal shoulder to control insertion depth, shown as dimension "L" on print 4012180-671. The area aft of the internal shoulder on the O.D. of the fitting is used as a sealing surface for the braze tool. There is also a shallow trough on these fittings for parting purposes.

TECHNICAL INFORMATION SERIES

NO. R66FPD47

FEASIBILITY STUDY TO DETERMINE THE EFFECTS OF BRAZ-
ING HEAVY WALL TUBING UTILIZING A HIGH FRE-
QUENCY SOURCE INDUCTION GENERATOR

The purpose of this study was to determine if the induction braze tools, the high frequency induction source and related equipment specified for brazing the tubing of the NASA low pressure system (Table V) can be utilized for brazing tubing of wall thicknesses required for the NASA high pressure system (Table VI).

Conditions Of TestMaterials

| A. <u>Tubing</u> <u>Size</u> | <u>Wall</u> <u>Thickness</u> | <u>Designation</u> | |
|---------------------------------|---------------------------------|--------------------|-----------------|
| | | <u>AMS</u> | <u>SAE</u> |
| .250 | 0.026 | 5570G and 557IB | 30321 and 50347 |
| .750 | 0.075 | 5570G and 557IB | 30321 and 30347 |
| 1.250 | 0.122 | 5570G and 557IB | 30321 and 30347 |
| 1.500 | 0.113 | 5570G and 557IB | 30321 and 30347 |
| 2.000 | 0.151 | 5570G and 557IB | 30321 and 30347 |
| 2.500 | 0.188 | 5570G and 557IB | 30321 and 30347 |

B. Braze Alloy - Gold 82% - Nickel 18% in round rings of rectangular wire.

C. Purge Gas - High Purity Argon.

D. Fittings - 347 Stainless Steel straight couplings - elbow and tees provided with an internal braze alloy groove. Drawings 4012180-638 and 4012180-629.

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TABLE V

Low And High Pressure Systems

| <u>Tube O.D.</u> | <u>Pressure System Wall Thickness</u> | | <u>Diffuser</u> |
|------------------|---------------------------------------|-------------|-----------------|
| | <u>Low</u> | <u>High</u> | |
| .250 | .020 | .026 | .006 |
| .750 | .049 | .075 | .026 |
| 1.250 | .083 | .122 | .039 |
| 1.500 | .095 | .113 | .018 |
| 2.000 | .095 | .151 | .056 |
| 2.500 | .120 | .188 | .068 |

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TABLE VI
POWER TIME CYCLES

| <u>Low Pressure Tubing</u> | | | <u>High Pressure Tubing</u> | | |
|----------------------------|--------------------------|-------------------------|-----------------------------|--------------------------|-------------------------|
| <u>Size</u> | <u>Power Setting</u> | <u>Time Seconds</u> | <u>Size</u> | <u>Power Setting</u> | <u>Time Seconds</u> |
| .250 | 12 | 20 | .250 | 12 | 24 |
| .750 | 13 | 35 | .750 | .4 | 60 |
| 1.250 | 15 | 60 | 1.250 | 18 | 120 |
| 1.500 | 15 | 60 | 1.500 | 20 | 120 |

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Fixturing

A lab. rig fixture, Figure No. 17-17A & 17B, was used for testing all sizes of tubing. This fixture is designed to provide argon protection during the brazing and cooling operations.

Tests

Sample joints of heavier wall thickness tubing were induction heated in the lab. rig fixture, using the power settings and time cycles previously established for brazing the low pressure system tubing. Two chromel-alumel thermocouples were used to determine the temperature of the joint being brazed. Each thermocouple was tweezer weld tacked in place on the I.D. of the tube being brazed. One thermocouple was located at the center of the coupling, the other thermocouple was located at the end of the coupling. Samples were inspected visually for brazing alloy flow. In the event, the joint did not reach braze temperature or braze alloy flow did not occur, the power setting and/or the time was increased in small increments, until a sound braze joint was obtained.

Test Results

The 1/4", 3/4", 1 1/4" and 1 1/2" braze joints exhibited good flow of braze alloy around the periphery of the fittings. The power time cycles used for obtaining these results were somewhat greater than those established for the low pressure system Table V. X-ray examination of these brazed samples revealed 80 to 100% coverage. Peel testing of these same samples verified the x-ray findings. Figure 18 is a 1 1/2" peeled joint. The 2" and 2 1/2" samples exhibited poor alloy flow for all power time cycles attempted. No acceptable couplings were obtained. X-ray and peel testing indicated 40 to 50% coverage. The power-time cycle required to obtain 40-50% braze coverage for the larger samples caused over heating of the power transmission cable. One to two hours was required to cool the cable before it could be used again.

Distortion of the 2" and 2 1/2" couplings occurred during the heating cycles. Figure 19 shows a typical example. The distortion was located near the end of the coupling where the wall is tapered. It was not found at the same point on the periphery of the coupling of all the samples prepared indicating that it was not due to a hot spot during the heating cycle.

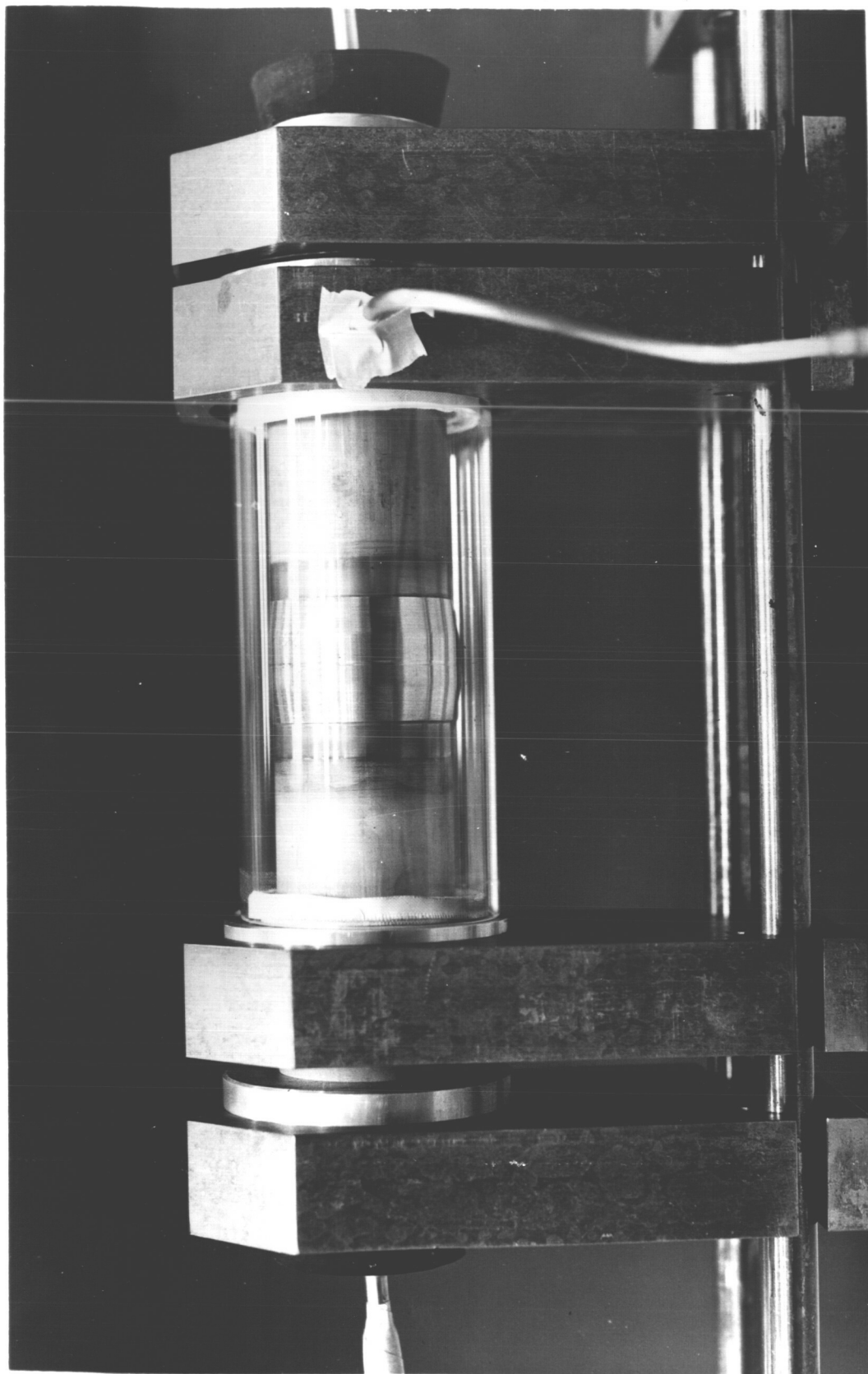


FIGURE 17

IAB BRAZE FIXTURE

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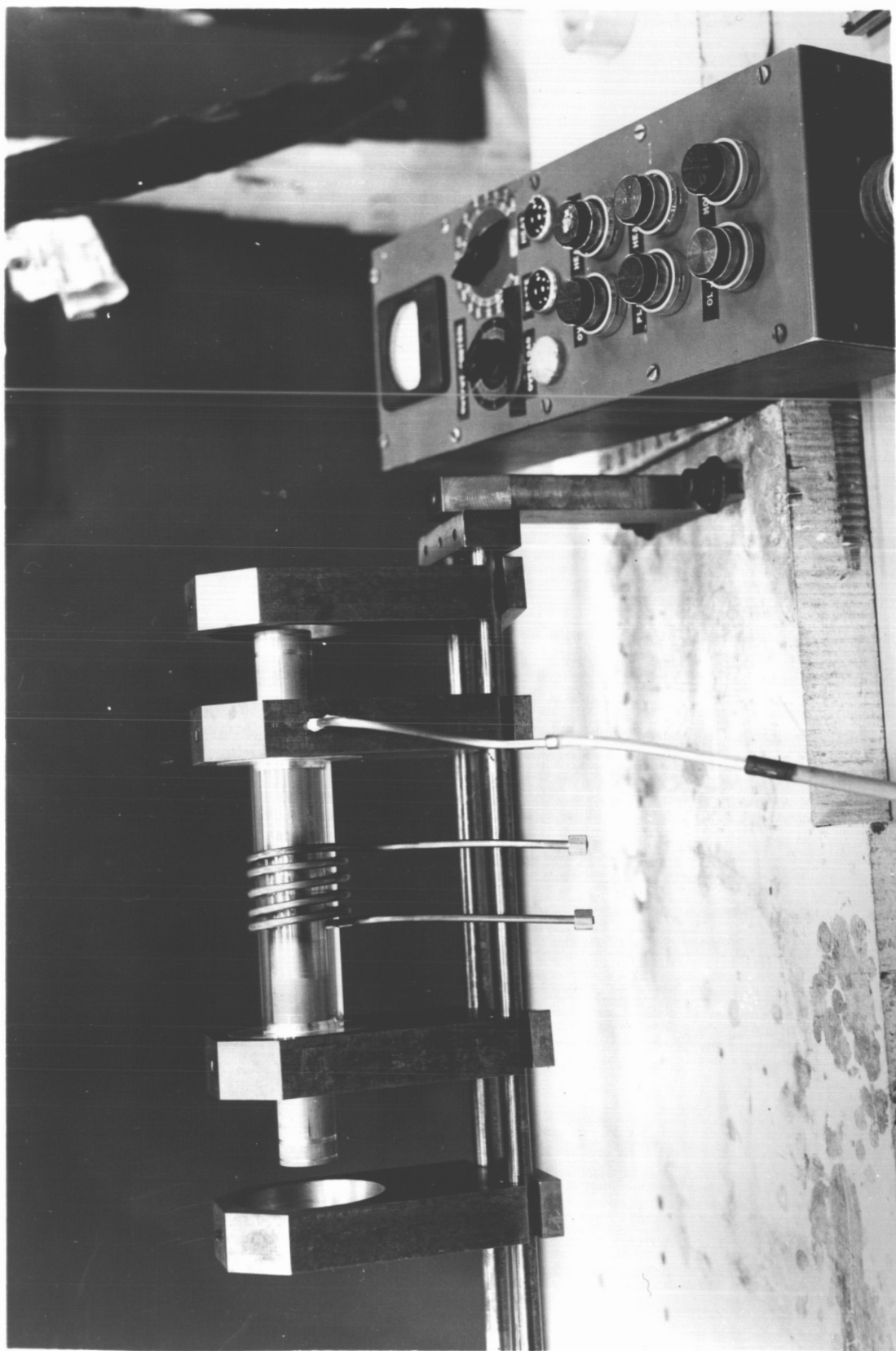


FIGURE 17A

LAB BRAZE FIXTURE

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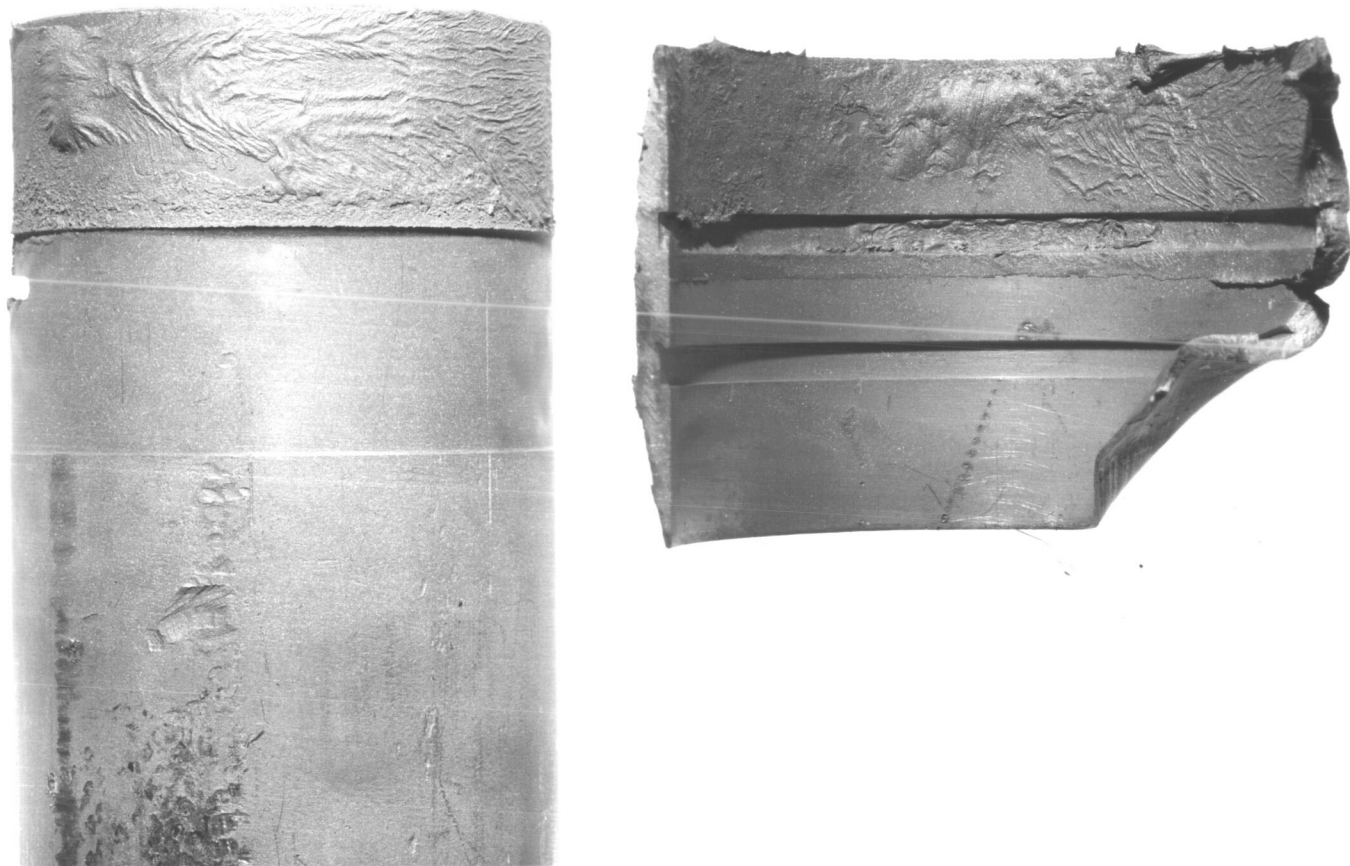


FIGURE 18

1 1/2" PEELED BRAZE JOINT

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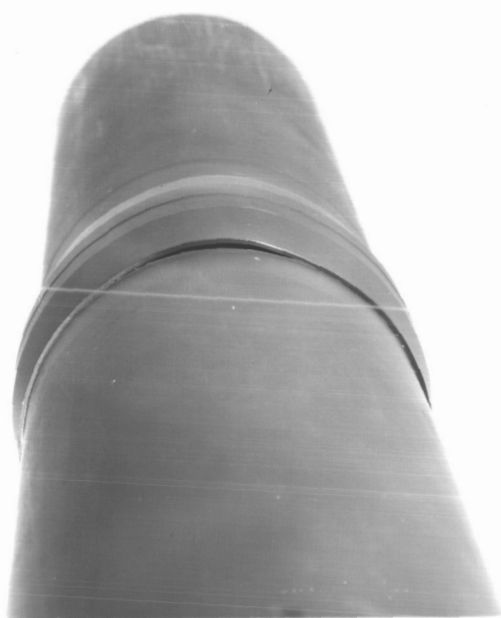


FIGURE 19

COUPLING DISTORTED AREA

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NO. R66FPD47

Conclusions

This investigation revealed that sound, high quality braze joints can be obtained in the 1/4", 3/4", 1 1/4" and 1 1/2" high pressure systems utilizing the present induction braze tools and related equipment. The 2" and 2 1/2" joints cannot be produced with our present braze tools and related equipment.

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STEEL SEALING JAWS

The RPD 150 sealing jaws in the 1 1/2", 2" and 2 1/2" straight couplings were replaced with a stainless steel jaw. The braze tools for brazing the elbow and tee type fittings were also modified in like manner. Enough heat reached the RPD 150 material to produce outgassing during continued use. The outgassing contaminated the atmosphere inside the chamber resulting in undesirable oxidation. The contamination problem was eliminated by the change to steel. It was felt that with the shorter width of tools for brazing elbow and tee fittings, it would be advisable to replace the plastic sealing jaws with stainless steel also. Replacements of these tools were completed and all tools tested. All braze tools tested satisfactory.

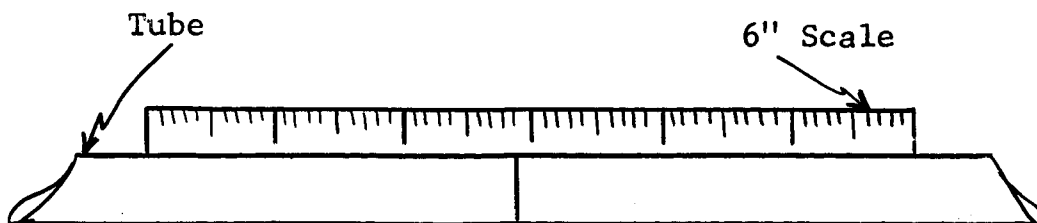
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TECHNICAL INFORMATION SERIES
NO. R66FPD47

RECOMMENDED OR SUGGESTED BRAZE PROCEDURE

Tubing Fit Up

- 1.1 Purpose: To cut, trim and align tube ends before the braze operation.
- 1.2 Set-up and Parts Protection: Using a blue print accumulation list and (if possible) a photo book check for routing, clamping and bracketing of the tubing before fit-up. Keep the tube ends capped at all times, except during brazing. Handle tubing carefully. Avoid unnecessary contact with other piping structural material and tooling.
- 1.3 When tube fitter has marked the tube or tubes for cut off, remove it if necessary to facilitate cutting. Be sure to plug the tube before cutting.
- 1.4 On final fit tube ends should mate in free state, or maximum gap of .030.
- 1.5 To determine proper alignment, lay a six inch scale (or straight edge).

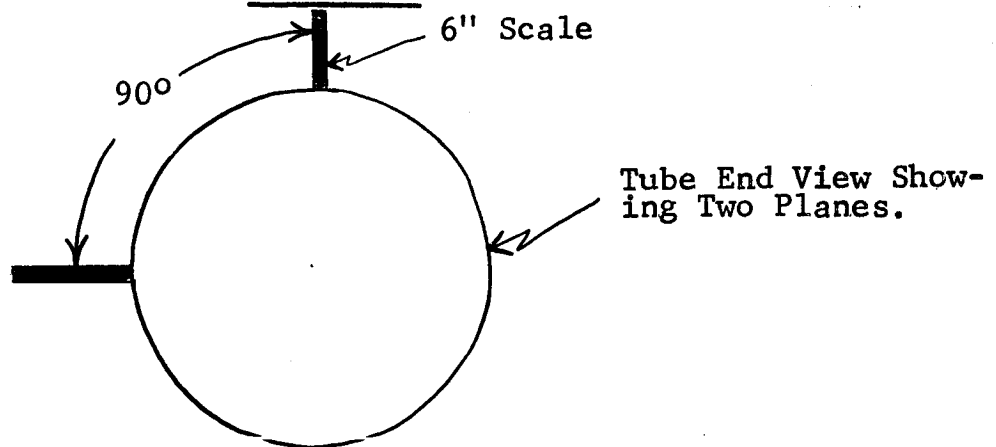
SKETCH I



TECHNICAL INFORMATION SERIES

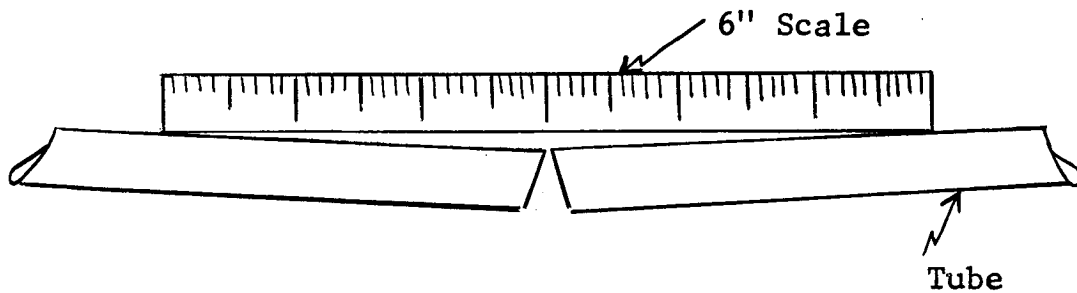
NO. R66FPD47

SKETCH II



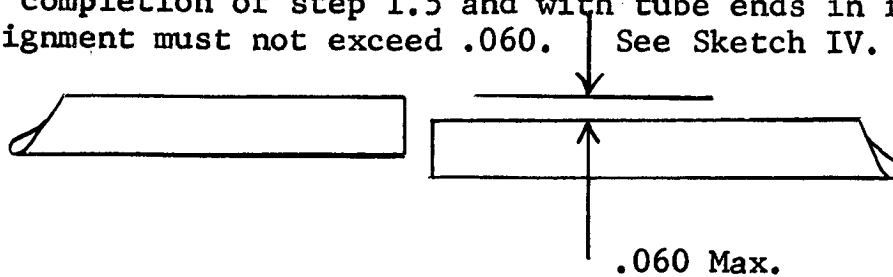
SKETCH III

Warning - Do not assemble joint as shown in Sketch III.



SKETCH IV

1.6 After completion of step 1.5 and with tube ends in free state, misalignment must not exceed .060. See Sketch IV.



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TECHNICAL INFORMATION SERIES
NO. R66FPD47

- 1.7 Realign end tube which is removed or disturbed after final alignment.

Tube Preparation

- 2.1 Purpose: Sizing is required to control the clearance between the coupling and the tube.

Masking is required to center the coupling on the joint and to assure control of the gap between tube ends.

A cleaning process is required to prepare the tube and tube ends for braze.

- 2.2 Sizing: The proper roll-a-finish size tool and split holding clamp should be set up on the sizing equipment. Secure tube in clamp and size tube ends. (A. sample piece of tubing should be run first to see if the roll-a-finish tool is set correctly to give the required diameter; this is especially true when sizing tubing of the same diameter, but of different wall thickness.)
- 2.3 Tube end should be wiped clean of all oil.
- 2.4 Tube end to be brazed should be roughened using 180 emery cloth. Tube end after sizing has too smooth a finish for brazing.
- 2.5 Some means of marking the tube end prior to final clean should be done now. A suggested method for use is an electric etch similar to that used for putting an identifying number on a tube.
- 2.6 Tube and tube end should now be cleaned to your specification, capped and bagged for brazing.

Inspection - Visual and Dimensional

- 3.1 Purpose: To provide the assembly inspector with an instruction by which to interpret and perform the various inspection functions necessary to assure successful processing of high integrity leak proof braze joints.

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TECHNICAL INFORMATION SERIES

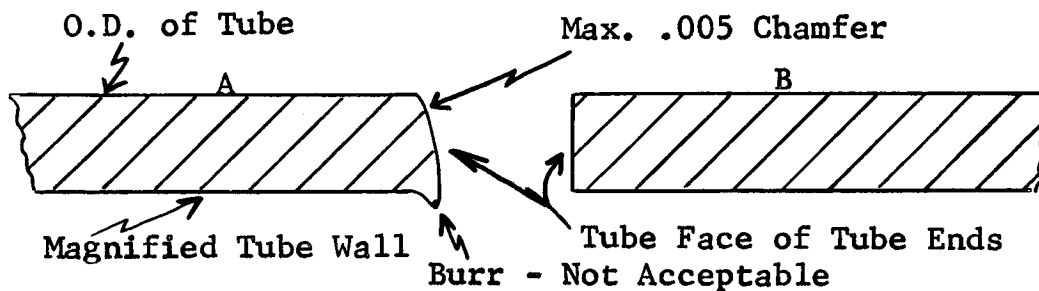
NO. R66FPD47

- 3.2 Preassembly Inspections - Tubing Only: Visual, inspect the tubing for dents. No dents allowed over a 2" length measured from tube end. No radius within the dent or between the dent and its adjacent tube surface shall be less than three times the nominal tube wall-thickness. Depth of dents not to exceed 10% of outside tube diameter. No dents allowed in bend radii or within one tube diameter of tangent points. More than two dents in any given axial inch of tube length is not allowed except on high pressure tubing. On high pressure tubing more than two dents in any given three consecutive axial inches of tube length is not allowed.
- 3.3 Visual: Inspect the tube ends and tubing for nicks and scratches. Depth of 10% of wall thickness on all but high pressure tubing. On hydraulic tubing, use 5% of wall thickness or .002 whichever is smaller.
- 3.4 Visual: Out of roundness shall not exceed 10% of the tube diameter over 1.75" length measured from the tube end.

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

- 3.5 Visual: Tube End - Inspect the trimmed tube end for squareness of the face, freedom of burrs in the I.D. and a maximum of .005 chamfer on the O.D. of the face. See Sketch V.

SKETCH V



Note: A) Not Acceptable
B) Acceptable

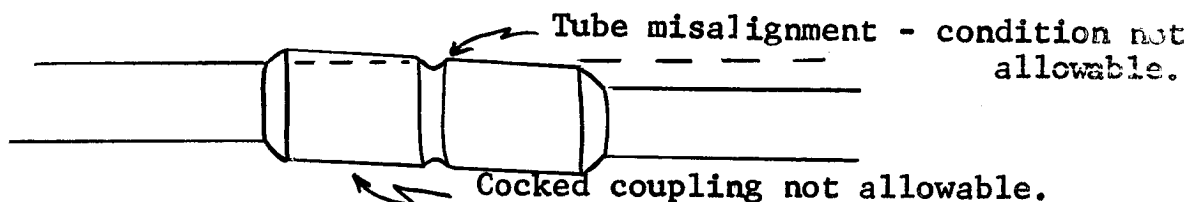
Use a brass scribe on the I.D. of tube ends if necessary to pick up the burr.

- 3.6 Visual: Corrosion - Inspect for rust or any form of dirty scale on tube O.D. - not allowed.
- 3.7 Visual: Centering Marks - Inspect the tube O.D. for presence of the coupling and tool centering marks. The marks (one per tube end) must be clear and distinct.

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

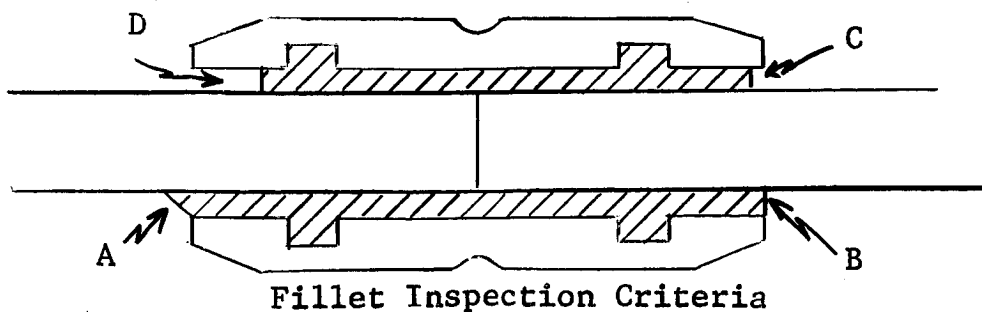
3.8 Final Braze Inspection: Visual - Inspect the brazed joint for tube misalignment and cocked coupling. See Sketch VI.

SKETCH VI



Visual: Using a localized light and a plain or magnifying mirror as needed, inspect the joint for evidence of a braze alloy fillet around the external tube/coupling entrance periphery; no gaps, voids or pinholes allowed. See Sketch VII.

SKETCH VII

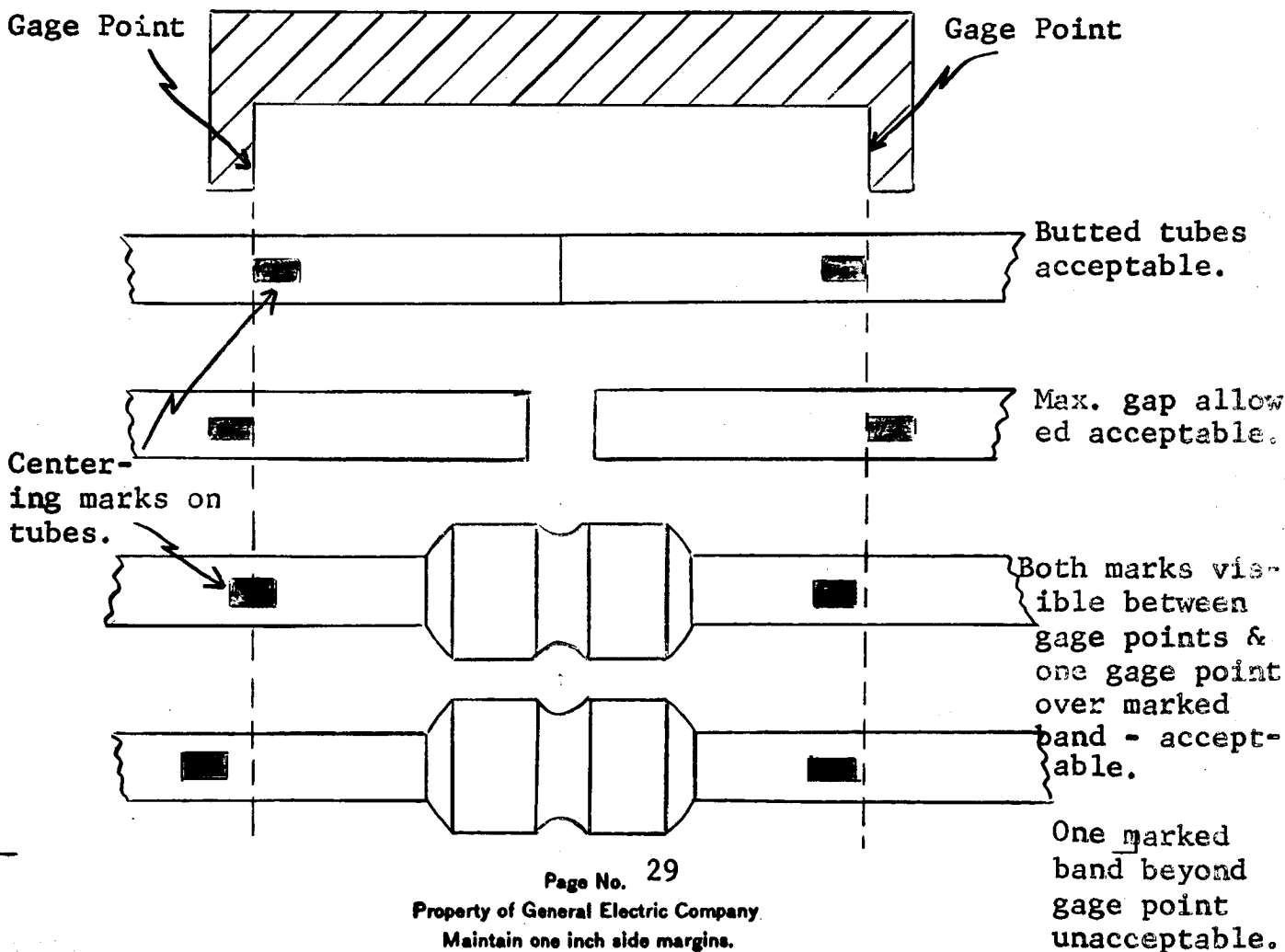


GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

- A. Braze alloy extends beyond edge of coupling. Fillet is plainly visible. This is acceptable.
- B. Braze alloy extends to the edge of coupling. Fillet is acceptable, if visible through a light and/or 10X glass.
- C. Braze alloy extends to the edge of coupling. Fillet requires light and 10X glass to see it. This is acceptable. Under cut must not exceed .03125.
- D. Braze alloy is not visible with light and 10X glass. Braze joint is not acceptable.

3.9 Dimensional: On coupling centering and tube gap. Using a fixture as shown in Sketch VIII inspect brazed tube joint.

SKETCH VIII



GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

- 4.1 Repair Procedure: This suggested repair procedure is for the repair of braze joints which after the first induction cycle with internally preplaced braze rings do not exhibit the presence of braze alloy completely around the tube/coupling interstice.
- 4.2 By visual inspection and measurements the sum total length of all voids at one coupling tube intersection must be less than the following lengths as measured circumferentially around the tube.

| <u>Joint Size</u> | <u>Max. Limit Inches</u> |
|-------------------|--------------------------|
| 1/4" | 5/32" |
| 3/4" | 15/32" |
| 1 1/4" | 5/8" |
| 1 1/2" | 3/4" |
| 2" | 1" |
| 2 1/2" | 1" |

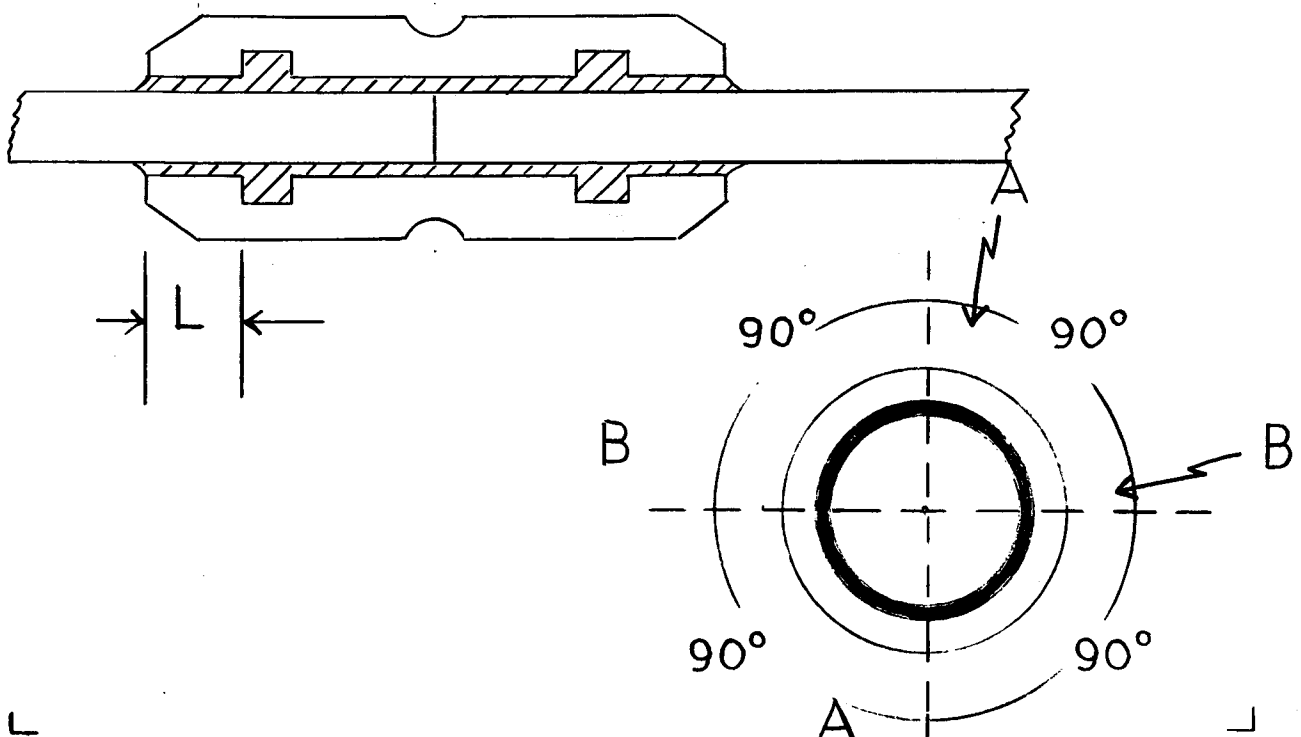
- 4.3 Locally clean the voided area - flush with distilled water. Flush with suitable solvent and let dry.
- 4.4 Wearing clean lint free gloves place a braze ring on the tube adjacent to the coupling side which is voided. No more than one braze ring per coupling side allowed.

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES

NO. R66FPD47

- 4.5 Purge joint in question sufficient time to achieve a good argon atmosphere - being sure all of solvent has evaporated. Repeat the brazing procedure assuring flow of external ring. No more than one reheat per joint allowed.
- 4.6 Visual Inspection: Visual inspect each joint using a localized light and a magnifying mirror. Joint must show evidence of a braze alloy fillet 360° around the external tube coupling entrance periphery; with no gaps, voids or pinholes. Examine questionable areas with a 10X magnifying glass. See Sketch VII of an acceptable joint.
- 4.7 X-ray the joint in two planes 90° apart. Inspect for voids in length L shown in Sketch IX. X-ray acceptable limits are defined in Table I.

SKETCH IX



GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES

NO. R66FPD47

X-ray inspection in plane A-A and B-B. The cumulative length of voids in one length "L" shall be considered one indication in Table I. Joints subjected to repair which do not meet this criteria after repair will be cut out and rebrazed.

TABLE I

| <u>Tubing Size</u> | <u>Allowable Limits</u> |
|---|--|
| 1/4" Dia. | One (1) .035" and three (3) .018 indications allowed per coupling end. |
| 3/4" Dia. | One (1) .077" and three (3) .038 indications allowed per coupling end. |
| 1 1/4" Dia. | One (1) .107" and three (3) .053 indications allowed per coupling end. |
| 1 1/2" Dia. | One (1) .137" and three (3) .063 indications allowed per coupling end. |
| 2" Dia. | One (1) .154" and three (3) .080 indications allowed per coupling end. |
| 2 1/2" Dia. | One (1) .171" and three (3) .098 indications allowed per coupling end. |
| No voids allowed within .015" of outboard ends of coupling. | |

5.0 Debraze

5.1 Purpose: To facilitate disassembly, repair or replacement of the brazed tubing.

5.2 Cut coupling in half and deburr tube ends.

Note: A nylon brush may be used to prevent entry of chips during the deburring operation.

5.3 Be sure tube is free of all fuel, oil or contaminants. Purge inside of tubing with argon until a good atmosphere is achieved.

5.4 Clamp on debrazing tool and heat coupling until it is hot enough to be removed. After removal of half coupling the

GENERAL ELECTRIC COMPANY
TECHNICAL INFORMATION SERIES
NO. R66FPD47

tube end must be cleaned prior to brazing.